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SEPTEMBER 1988
TASK NO. 27
VOLUME II - APPENDICES

HAZARDOUS WASTE LAND DISPOSAL FACILITY ASSESSMENT

CONTRACT NO. DAAK11-84-D-0017

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ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

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APPENDIX I

WASTE CHARACTERIZATION

I.0 WASTE CHARACTERIZATION

I.1 PURPOSE

The waste characterization chapter will address information needs for the land disposal facility concept design. These information needs are waste volume, waste type, waste form, chemical and physical properties of wastes at RMA, and waste location. The RMA waste estimates were based on borings and historic data in support of calculations using best engineering judgment. These estimates are a synthesis of reportedly conservative volume estimates from earlier studies of RMA and other estimates developed from the ongoing investigations of RMA's potentially contaminated sites, spill areas, and buildings.

The waste volumes were used to size the facility. The waste volumes were described by waste types and waste forms. This information was used in the evaluation of the land disposal facility's waste cell concept designs. Chemical and physical properties and locations of RMA wastes were factors in waste control design criteria, barrier system selection, facility siting, waste placement operations, and support facility requirements. These factors will be described in later chapters.

I.2 WASTE CHARACTERIZATION METHODOLOGY

The waste characterization methodology was based on a literature review and contact with current investigators to estimate RMA wastes of all contaminant types. RMA waste estimates were developed from a review of more than 100 applicable documents estimating quantities of potentially contaminated materials such as soil and building debris. No liquid wastes were considered in the current estimate due to regulatory bans on liquid waste disposal in land disposal facilities from the 1984 amendment to the Resource Conservation and Recovery Act (RCRA).

For the purposes of this task, all liquid wastes were assumed to be treated to a solid residue. Waste volume estimates included an allowance for liquid waste treatment residues.

Previous studies identified 165 sites that were investigated for potential chemical contamination, and 88 sites were identified as potentially contaminated. In addition to these previously identified contaminated sites, investigations of other areas of RMA were conducted. These investigations were part of remedial investigations (RIs) for CERCLA (ESE, 1986a). All contaminated sites will be summarized by section number, with a current contaminated materials estimate for each numbered site as well as building debris estimates by RMA section as appropriate.

Previous waste estimate studies, such as the the Decontamination Assessment of Land and Facilities at RMA (DALF)(RMACCPMT, 1984/RIC 84034R01), identified three types of potentially contaminated waste: hazardous and toxic materials, unexploded ordnance (UXO), and materials exposed to chemical warfare agents. These waste types will be described as to their importance to waste processing, hauling, and disposal operations.

The decontamination of all contaminated sites at RMA will generate both solid wastes and some liquid wastes (i.e., decontamination water or leachate). The liquid waste, as stated earlier, will not be disposed at the proposed land disposal facility. The liquid could be treated in a leachate treatment or other liquid treatment facility, and the solid residues subsequently disposed at the facility. The solid waste volume will consist primarily of two waste forms: potentially contaminated soil and building debris. These solid waste forms will be the products of contaminated soil excavation and building demolition and are assumed to be placed in the proposed on-site land disposal facility for purposes of this study.

The volume estimates of all contaminated sites were the most current information available for the quantity of potentially contaminated soils and buildings. The estimate of potentially contaminated materials is referred to as the expected waste volume estimate, in bank cubic yards (bcy), a bcy is one cubic yard of material as it rests in a site. Expansion and compaction factors will be applied to the expected-volume estimate. These factors will be used to estimate the volume of contaminated materials hauled to the disposal site as well as to estimate the compacted volume of waste in the land disposal facility. Both expansion and compaction factors will be developed for the various waste types and forms.

Chemical and physical properties of RMA waste were also basic items in waste characterization. Since RMA wastes displayed diverse properties, selected RMA wastes will be described to reflect the range of chemical and physical properties important to the planning of the land disposal facility.

Waste locations are another important consideration for the location of the land disposal facility. The closer the facility is to the centroid of major contaminated material volumes, the lower the cost in waste hauling or transportation. The waste centroid was determined based on a volume times distance calculation, which will be done for the RMA waste sites with over 20,000 bcy. The chosen RMA waste sites, waste volumes, and waste centroid are presented on Figure I-1.

I.3 REVIEW OF PAST WASTE CHARACTERIZATION STUDIES

The documents described in Appendix A - Bibliography were reviewed. The DALF and the current Remedial Investigation/Feasibility Studies (RI/FS) of Ebasco Services Incorporated (Ebasco) and Environmental Science and Engineering, Incorporated, (ESE) for the U.S. Army Program Manager's Office for Rocky Mountain Arsenal Contamination Cleanup (PMO) were the best sources of waste characterization information. These documents are briefly summarized in the following sections.

TABLE I-1

SUMMARY OF CONTAMINATED MATERIAL VOLUMES IN DALF[1]

	Waste Form		Waste Type			
Section Number	Excavation Volume (bcy)[2]	Building and Equipment Volume (cy)	Volume of Toxic and Hazardous (bcy)	UXO Volume (bcy)	Surety Volume (bcy)	Total Section Volume (bcy) [2]
24	96,000		96,000	--	--	96,000
19	1,000	--	992	8	--	1,000
20	1,000	--	992	8	--	1,000
26	4,322,000	--	4,322,000	--	--	4,322,000
25	18,000	29,300	18,000	--	29,300	47,000
30	407,000	--	317,388	1,612	88,000	407,000
29	254,000	--	252,306	1,694	--	254,000
35	118,000	--	117,535	465	--	118,000
36	5,526,000	--	812,826	2,777	4,710,397	5,526,000
31	169,000	--	--	--	169,000	169,000
32	148,000	--	147,808	192	--	148,000
4	374,000	--	374,000	--	--	374,000
3	32,000	--	32,000	--	--	32,000
2	1,733,000	12,310	1,602,291	9	143,010	1,745,000
1	2,203,000	23,400	2,025,200	--	201,200	2,226,000
6	97,000	--	--	--	97,000	97,000
5	147,000	--	--	--	147,000	147,000
11	53,000	--	53,000	--	--	53,000
12	119,000	--	119,000	--	--	119,000
TOTALS	15,818,000	65,010	10,291,338	6,765	5,584,907	15,883,000

1/ DALF, 1984.

2/ Volume rounded to nearest thousand bank cubic yards.

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I.3.1 Decontamination Assessment of Land and Facilities at RMA, 1984

The "Decontamination Assessment of Land and Facilities at RMA" (DALF) study presented the evaluations and findings of the RMA Contamination Control Program Management Team (RMACCPMT 1984/RIC 84034R01, hereafter cited as DALF, 1984). The report documented the results of several years of study to assess the feasibility and cost of decontaminating all or portions of RMA.

The methodology used for the study involved: 1) review of applicable Federal and state requirements affecting decontamination of government real property; 2) review of existing data to define areas, types, and volumes of contaminated materials at RMA; 3) development of technical approaches to decontaminate RMA property; and 4) estimation of costs that would be incurred to allow both partial and total unrestricted use of RMA. The DALF evaluated procedures that could be used to handle, process, and dispose of unexploded ordnance, contaminated buildings and equipment, toxic and hazardous materials, and surety agents.

Soil removal volumes were calculated by multiplying the estimated areal extent of the contaminated sites by a depth estimate based on historic activities conducted at the sites and on the available geologic information. The estimated areal extent of contamination and volume estimate for each site is shown in Attachment A, Table A-1. A summary of volume estimates by land section is presented in Table I-1. The DALF study estimates a total of about 16 million bcy of contaminated soil, buildings, and equipment from the 88 potentially contaminated RMA sites.

In addition to the contaminated wastes, about 2.31 million square feet of uncontaminated buildings and structures were identified that would also be demolished for disposal but were not included in the 16 million bcy estimate.

I.3.2 Results of Ebasco Services Incorporated's Remedial Investigation and Feasibility Study Tasks at RMA

The Ebasco RI/FS results of Tasks 2, 7, 10, 11, 12, 15, 17, 24, and 34 provided data on potentially contaminated materials, primarily contaminated soils and buildings at more than 60 sites and 1,200 structure locations. The

Ebasco studies described the volume of potentially contaminated materials using indicator levels of target analyte concentrations. Indicator levels are the lowest levels that can be detected, or in the case of metals, the background levels. These potentially contaminated materials volume estimates are subject to revision upon establishment of action levels of target analytes, which will permit eventual identification of the actual inventory of waste requiring remediation at RMA.

A detailed presentation of estimates of potentially contaminated material drawn from the more than 45 Ebasco contamination assessment reports (CARs), cross-referenced to RMA task numbers, is presented in Attachment A, Table A-2. The sources used to make Table A-2 are also listed in Attachment A. These potentially contaminated material volume estimates are based on review of historical information, soil borings, site geology, hydrology, soil contaminant levels, and building decontamination assessments. This site information was summarized by RMA section and site for contaminated soil and by RMA section for the buildings.

I.3.3 Results of Environmental Science and Engineering, Incorporated's Remedial Investigations and Feasibility Study Tasks at RMA

The ESE RI/FS task results that were useful for waste volume estimates for the contaminated sites at RMA were Tasks 1, 6, 14, and 21. These tasks encompassed more than 45 CARs, with particular emphasis on major potentially contaminated sites in Sections 26 and 36. ESE volume estimating procedures were similar to those described for the Ebasco RI/FS studies. A summary of expected volumes of potentially contaminated materials is presented in Attachment A, Table A-2. The ESE CARs were the source of many of the potentially contaminated material estimates listed in Appendix A - Bibliography. The ESE CARs found potentially hazardous and toxic materials to be the primary waste at RMA sites investigated; however, some potentially agent-contaminated materials and UXOs (i.e., bursters) were also identified.

I.3.4 Current Waste Volume Estimates

The DALF, Ebasco, and ESE studies have provided estimates of potentially contaminated materials as shown in Attachment A, Table A-2. This estimate represents the bank volume of waste; however, the excavation of soil and demolition of buildings creates an expanded-volume or loose condition that requires a loose cubic yard (lcy) estimate. Much of the near-surface geology of RMA is Pleistocene alluvium (May, 1982/RIC 82295R01). Surface soil material can consist of sand, silty sand, or silty clayey sand (USDA 1974). The expanded volume can be between 1.1 to 1.2 times the bank volume for sand or sand and clay (Caterpillar, 1981 p. 500). A 1.15 expansion factor is, therefore, used for conversion of the contaminated bank volume estimates to loose volume estimates for purposes of establishing waste hauling requirements.

The compacted volume factor for contaminated soils, placed in a land disposal facility waste cell, could range from 1.0 to 0.85 compared to the bank volume estimates (Caterpillar, 1981 p. 500). A 0.95 compaction factor was selected as a reasonable estimate for purposes of estimating compacted contaminated soil volumes as they would reside in the disposal facility. These volume estimates were used for sizing the land disposal facility.

The exceptions to the above expansion and compaction factor estimates are as follows:

- Basin F, Site 26-6, is an identified source of heavily contaminated waste, some of which appears to be hazardous waste, and all of which will likely be treated prior to disposal (Ebasco, 1985; Ebasco, 1986a). Heavy contaminated waste for purposes of this estimate are wastes that contain target analytes to 9 levels of 3 or more orders of magnitude greater than the indicator levels given in Attachment B. While the treatment processes have not been selected for Basin F materials, the treatment processes could expand the expected volume of disposed waste by a factor of 2.0 if chemical stabilization/fixation is selected (Conner, 1986; Meyers, 1985; Landreth, 1982). This factor is conservatively applied to the bank volume of Basin F materials to obtain the compacted volume estimate in the disposal facility and reflects the potential for further discovery of heavily contaminated materials that will require treatment.

- Building debris can expand from its bank volume by as much as 1.5 (Ebasco, 1987). The recompacted volume of demolition waste is variable and is less than the expanded volume by as much as a factor of 0.8 (Tchobanoglous, 1977), or 1.2 times the original volume.

It is assumed that unexploded ordnance would be demilitarized with little or no hazardous waste generated in the process (DALF, 1984). Volume estimates for UXO will therefore be treated as contaminated soil.

Surety-contaminated material may be subjected to thermal treatment so as to comply with DARCOM Regulation No. 385-102, p. 5-1 (DALF, 1984). This treated material will subsequently be handled similarly to contaminated soil.

The summary of the estimated (bcy), expanded (lcy), and disposal (ccy) volumes calculations for each site is shown in Attachment A, Table A-2. Waste volumes by RMA section are presented in Table I-2, which presents the current estimates for the expected bank volumes and applies the factors described above to obtain the expanded and disposed volumes. Table I-2 is used as the conceptual basis for the design capacity of the land disposal facility.

To put the estimated volume of material in perspective, the 16.5 million l cy of material is equal to approximately 110,000 standard 150 cy railroad coal-carrying cars or 660,000 25 cy trucks. If all of the potentially contaminated material were moved off-site at the rate of one 100 car train or 100 trucks per weekday, it would take approximately 4.4 years by rail and 26.6 years by truck to move all of this material.

Three factors could change the current estimates as represented in Table I-2. They are the RMA groundwater cleanup strategy, land use plan, and final results of remedial investigations and feasibility studies. These factors can increase or decrease the potentially contaminated soil volumes to be disposed.

TABLE I-2

EBASCO SUMMARY OF WASTE VOLUME ESTIMATES BY SECTION[1/]

RMA Section	Estimated Volume (bcy)[2/]	Expanded Volume (lcy)[2/]	Disposal Volume (ccy)[2/]
1	2,180,800	2,518,900	2,079,900
2	1,716,000	1,978,100	1,633,500
3	47,800	55,000	45,500
4	444,000	510,700	421,900
5	147,000	169,100	139,700
6	97,000	111,600	92,200
7	---	---	---
8	---	---	---
9	---	---	---
11	53,000	61,000	50,400
12	244,000	280,600	231,800
19	1,000	1,200	1,000
20	1,000	1,200	1,000
22	---	---	---
23	---	---	---
24	96,000	110,400	91,200
25	47,300	64,700	52,300
26	3,250,000	4,259,000	3,732,300
27	---	---	---
28	---	---	---
29	34,200	39,400	32,500
30	163,600	188,200	155,500
31	169,000	194,500	160,700
32	140,000	161,100	133,100
33	---	---	---
34	---	---	---
35	122,000	140,400	116,000
36	3,630,900	4,178,200	3,451,600
TOTAL[3/]	12,586,600	15,023,800	12,622,100

1/ Rounded to nearest 100 cubic yards.
2/ bcy: bank cubic yards; lcy: loose cubic yards; ccy: compacted cubic yards
3/ The volume estimate is used as the conceptual design basis for Task 27. It represents the best information available as of February 6, 1987 with the exception of Section 26 where an April 1987, volume estimate is incorporated.

RMA cleanup alternatives may include emphasis on groundwater pumping and treatment, capping, in situ treatment, or selected incineration of contaminated materials prior to disposal. The groundwater cleanup strategy may result in the exclusion of certain sites from excavation based on low soil contaminant concentrations leading to a determination that a no-action alternative or an alternative technology, such as capping, most effectively limits the risk to public health and safety.

The second factor that could modify soil excavation estimates is the land use plan, which will affect what action levels are developed from the Preliminary Pollutant Limit Values (PPLVs) and applied to decisionmaking in excavating contaminated soils. PPLV is a contaminant concentration level, where risk assessment modeling suggests concerns for health risks due to the exposure of the public to a particular contaminant. PPLVs will vary depending on land use decisions reflecting the ultimate disposition of the Arsenal area. Soil concentration PPLVs lower than indicator levels for target analytes could translate into action levels that increase the site cleanup excavation volume estimates by a significant amount. The converse of this situation is the choice of PPLVs above target analyte indicator levels, which could mean action levels, that reduce excavation volumes of potentially contaminated material from the current estimates.

The third modifying factor is that results of the remedial investigations and feasibility studies at many sites are not completed. Upon completion of these studies, contaminated soil volumes estimates may significantly decrease or increase as noted in Attachment A - Table A-2.

I.4 WASTE TYPES

The potentially contaminated materials at RMA were classified into three waste types: hazardous and toxic materials, unexploded ordnance, and surety-contaminated materials. These waste types applied to the nature of the contamination of the two major waste forms, contaminated soils and building debris. More than 60 chemicals, from a list of over 666 chemicals used at RMA or degraded products of these chemicals, were considered target analytes for analysis of potentially contaminated soils and building debris (G&M, 1986; Ebasco, 1986). Attachment B presents a list of target analytes, indicator levels, and waste types.

I.4.1 Hazardous and Toxic Materials

The Ebasco studies described the volume of potentially contaminated materials using indicator levels of target analyte concentrations. Indicator levels were the lowest levels that could be detected, or in the case of metals, the background levels. These potentially contaminated materials volume estimates are subject to revision upon establishment of action levels of target analytes, which will permit eventual identification of the actual inventory of waste requiring remediation at RMA.

While the DALF estimated 10.3 million bcy of hazardous and toxic contaminated soils and building debris, the current studies as of February 6, 1987, lead to an estimate of 13.3 million bcy, representing almost all of the RMA waste (Table I-2).

I.4.2 Unexploded Ordnance

Of the more than 88 sites identified in the DALF as containing hazardous and toxic materials, 18 were identified as also containing, or possibly containing, unexploded ordnance (UXO). The two basic types of ordnance that might be found at RMA include high explosive (HE) and surety materials. The total volume estimate is almost 7,000 cubic yards of UXO waste, based on the assumption that test sites, mortar ranges, bomb drop areas, and demolition grounds contained 0.1 percent by volume of UXOs. All surety UXOs were expected to be found within Section 36, and the remaining UXOs were assumed to be of the high-explosive (HE) type. All the above estimates are from the DALF.

The current RI/FS studies by Ebasco and ESE (see Attachment A - Bibliography) identified a potential 450 bcy of UXO wastes at potentially contaminated Site 30-1 (ESE 1986b). Since the UXO waste would be demilitarized before disposal, this waste type will be incorporated into the contaminated soil volume estimate for the design of the land disposal facility.

I.4.3 Potentially Agent Contaminated Materials

Potentially agent-contaminated material (PACM) is soils or other solid wastes that, through post exposure to chemical warfare agents, contain detectable levels of agents or their byproducts. These agents attack the blood, the nervous system, or the skin to cause injury or death in their active or concentrated states (G&M, 1986). These materials can potentially degrade into chemical contaminants in the soil, as shown in Appendix B. Examples of these materials are mustard gas and Sarin. The toxic character of surety materials and some of their degradation products may cause them to require special thermal treatment.

The DALF study estimated 5.6 million bcy of potentially agent-contaminated materials at RMA. The Phase I CARs have identified significantly less PACM. Site 36-17, a complex disposal activity site, identified mustard contaminated soils that will require Phase II investigation before a determination of surety materials quantities can be made. It is assumed that PACMs will be treated if detectable level of chemical warfare agents are discovered before the PACMs are disposed at the hazardous waste landfill. The volume of PACMs is incorporated into the contaminated soil volume/estimate.

I.5 WASTE FORMS

Waste form denotes the structure of the waste. The two basic waste forms are building debris and excavated soils. Of these waste forms, the excavated soil volume is by far the larger. Of particular importance is the division of soils into lightly contaminated and heavily contaminated soil categories. These categories of contaminated soil indicate the need for flexible designs, with regard to the volume of waste and the relative volume of each type of waste that may be handled and disposed of at a land disposal facility.

I.5.1 Building Debris

More than 1,200 structures on RMA, including 566 buildings, 132 tanks, and 220 transformers, were assessed for their potential contamination under Task 24. It is assumed for Task 27, as a worse-case, that essentially all contaminated buildings will be removed and disposed in an on-site land disposal facility.

Uncontaminated buildings would be disposed in another on-site appropriate areas. The placement of this contaminated debris would be in the center portion of the waste cells of the land disposal facility to minimize the mechanical hazard to barriers due to handling or settling.

The buildings' volume includes any associated equipment, tanks, piping, and utilities. The equipment items, like many of the structural items, are bulky and will require handling equipment that differs from that used for contaminated soil.

Material from building demolition will generally consist of concrete and masonry rubble, wood, steel sheets, and miscellaneous steel. The size of the material to be disposed will range from fist-sized chunks of concrete to substantially larger pieces that will require lifting equipment such as front-end loaders. Steel sheets of various sizes will be obtained from roofs, walls, or tanks. Wood and steel debris will vary in length and will be reduced to sizes cost effective for transport and disposal.

The preliminary demolition estimate of contaminated buildings and structures is about 65,000 bcy (DALF, 1984). An expansion factor of 1.5 will be applied to the bank volume estimate of building debris to obtain a loose volume of about 98,000 lcy. The compacted volume of building debris is estimated at 0.8 times the loose volume estimate, based on concrete and brick being a primary demolition waste (Tchobanoglous, 1977).

In addition to the standard building debris, there will be liquid or gaseous hazardous materials, PCB-contaminated equipment, and asbestos in the more than 650 buildings at RMA (Ebasco, 1987; Lund, 1982). The liquid wastes will be treated. The solid waste will be handled in a small special waste handling area for asbestos, rinsed transformer cases, and empty fuel tanks or compressed gas cylinders. Based on detailed decommissioning work by Ebasco (1987), 1 percent of the demolition waste may be such special waste, or about 6,000 lcy based on current estimates of contaminated and uncontaminated building demolition volumes.

The description of this demolition waste is expected to change with more detailed assessment of building contamination in RMA Task 24. If these future studies find additional contaminated materials, the new volume would be added to the design capacity of the land disposal facility.

I.5.2 Excavated Soil

Heavily contaminated soil is defined, for the purposes of this task, as soil materials having some target analyte concentrations three or more orders of magnitude greater than detection limits. The soil underlying the Basin F liner is heavily contaminated at certain boring locations (ESE, 1987c). The ESE estimate of 614,000 bcy reflects the most recent information regarding these heavily contaminated materials exclusive of findings reported after 2/6/87. Other heavily contaminated areas are anticipated in Basin A and South Plants as the Phase II CAR investigation are completed. Table I-3 presents a summary of analyses of these heavily contaminated soils.

The Basin F liquid, liner overburden, and liner are the only heavily contaminated materials at RMA that are presently identified as suspected hazardous wastes (Myers & Thompson, 1982/RIC 82350R01). These hazardous wastes are defined as wastes that will not pass the tests of 40 CFR 261.20 characteristics of hazardous wastes.

Ongoing studies under other tasks will refine the quantity of heavily contaminated materials from Site 26-6 and other RMA sites that belong in this category and may require treatment before disposal in the hazardous waste landfill. The treatment of Basin F materials is beyond the scope of Task 27; however, it is assumed for the purposes of this task that Basin F material will receive treatment before its final disposal to reduce the concentration or mobility of more than 20 target analytes, such as the volatile and semivolatile organic chemicals and the metals. Such treatment will help ensure that the land disposal facility barriers are compatible with the treated wastes. This will be discussed in more detail below and in Section 6. The expansion and compaction factor will be 2.0 (twice the bank volume estimate) to reflect the fixation or solidification of Basin F materials and allow for possible discovery of other heavily contaminated site areas during Phase II CAR investigations.

TABLE I-3
CONCENTRATIONS OF CONTAMINANTS IN SOIL SAMPLES UNDERLYING BASIN F LINER

Constituents	Number of Detections*	Concentrations (ug/g) Range	Mean	Median	ESE Standard Deviation	MRI Limit (ug/g)	Detection Limit (ug/g)	Detection
Volatiles (N=40)								
Chlorobenzene	2	0.8-5	3	3	3	0.3	0.3	
$CHCl_3$	3	0.3-70	30	4	40	0.3	0.7	
1,2-Dichloroethane	1	1	--	--	--	0.3	0.4	
BCHD	5	2-30	9	5	10	0.3	0.8	
BCHD	1	25	--	--	--	--	--	
Ethylbenzene	2	1-8	5	5	5	0.3	0.4	
Tetrachloroethene	7	1-40	10	10	10	0.3	0.5	
Tetrachloroethene	1	25	--	--	--	--	--	
Toluene	7	1-1000	400	300	400	0.3	0.3	
Toluene	--	25	--	--	--	--	--	
1,1,1-Trichloroethane	1	0.4	--	--	--	0.3	0.5	
m,xylene	2	0.4-5	2	2	3	0.3	--	
MIBK	2	0.4-1	0.7	0.7	0.4	0.5	0.4	
DMDS	3	2-60	30	10	30	0.3	4.0	
Benzene	3	1-3	2	2	1	0.3	1.0	
o,p-xylene	1	10	--	--	--	0.5	0.5	
Semi-Volatiles (N=40)								
Aldrin	9	0.7-4000	1000	1000	1000	0.9	0.5	
Dieldrin	7	100-2000	500	400	500	0.3	0.6	
Endrin	7	90-900	500	400	300	0.7	4.0	
DIMP	2	0.5-0.8	0.6	0.7	0.2	0.5	3.0	
Isodrin	7	100-3000	1000	1000	1000	0.3	0.6	
DCPD	7	30-4000	1000	600	1000	0.3	6.0	
DBCP	7	0.044-8.1	2.4	0.86	3.0	0.005	0.005	
PCPMS	3	6-700	400	400	400	0.3	0.3	
PCPMSO	5	4-70	20	5	30	0.4	1.0	
DMMP	6	3-70	20	7	30	2	3.0	
$PCPMSO_2$	14	0.5-300	30	5	70	0.3	0.4	
Metals (N=40)								
Cadmium	1	2.0	--	--	--	0.9	0.5	
Chromium	36	11-34	19	18	5.6	7.2	7.4	
Copper	40	5.0-2300	85	16	370	4.8	4.9	
Lead	4	18-35	24	21	7.7	17	16	
Zinc	35	33-320	68	57	49	16	28	
Arsenic	20	4.8-18	9.6	9.2	3.6	4.7	5.2	
Mercury	1	0.08-0.08	0.08	0.08	0.08	0.05	0.07	

* Number of samples in which constituent was detected.
N = Number of samples analyzed.
Source: ESE, 1986c.

Lightly contaminated soils are defined, for the purposes of this task, as potentially contaminated materials with target analyte concentrations within two orders of magnitude of the indicator levels. These wastes are also suspected hazardous wastes. They contain lower levels of hazardous and toxic chemicals than the heavily contaminated soils, and except for a few cases, where chemicals on the EPA Prohibited Subatance List are found, they would likely pass the extraction procedure tests (CRF 261.24). Table I-4 provides an example of contaminants and their concentrations detected in 34 samples from this category of lightly contaminated soils, in this case from the South Plants area.

As of February 6, 1987, the volume estimate of contaminated soil is about 12.6 million bcy, 15.0 million lcy and 12.6 million ccy for land disposal facility design purposes. This estimate represents all wastes, including Basin F contaminated materials and other heavily contaminated or agent-contaminated material, that are expected to be treated before disposal in the hazardous waste landfill.

I.6 CHEMICAL PROPERTIES OF WASTES

This section will discuss measured target analyte levels, waste-to-waste compatibility, and waste-to-barrier interactions. These properties are of importance to waste control so that incompatible wastes can be segregated into different waste cells for disposal. This section will provide a general discussion for concept design purposes because chemical properties may not be completely defined for all potentially contaminated sites. This review will identify potential problem areas for waste placement.

I.6.1 Measured Levels of Target Analytes

A summary of measured contaminants at RMA is presented in Table I-5, which was compiled from the USATHAMA database of soil boring data. The "hits" are contaminant levels greater than the specific analyte detection levels or indicator levels. The average for hit levels is shown for 49 analytes in Table I-5. Each average represents an estimate of concentration levels of that analyte in soils potentially contaminated with that analyte. The average analyte levels range from 0.1 to 200 ppm. While the information is not weighted for soil quantity as well as chemical concentration, it is useful for

TABLE I-4

ANALYSIS OF DATA ON CHEMICAL CONSTITUENTS DETECTED DURING PHASE I FIELD STUDY OF BURIED SLUDGE*

Constituent Detected Level	Number of Samples1/	Concentration (ug/g) Range	Median2/	Standard	Detection Mean2/	UBTL Detection Deviation2/	CAL Indicator Limit	Limit
Volatiles (N=3)3/								
None detected								
Semivolatiles (N=34)								
Aldrin	5	0.4-20	7	7	8	0.3	0.3	DL
Chlordane	1	7	-	-	-	2	0.6	DL
Dieldrin	7	0.5-20	0.6	7	9	0.3	0.3	DL
Endrin	1	3	-	-	-	0.5	0.3	DL
Hexachlorocyclopentadiene	1	1	-	-	-	0.6	0.3	DL
Dibromochloropropane (N=34)	1	0.018	-	-	-	0.0050	0.014	DL
ICP Metals (N=34)								
Cadmium	1	1.1	-	-	-	0.74	0.66	1.0-2.0
Chromium	18	6.6-16	8.8	9.7	2.4	6.5	5.2	25-40
Copper	24	5.6-32	7.5	10	6.4	4.7	4.9	20-35
Lead	4	14-26	-	-	-	8.4	13	25-40
Zinc	34	12-57	27	28	9.6	8.7	9.5	60-80
Arsenic (N=34)	1	3.0	-	-	-	2.5	5.0	DL-10
Mercury (N=34)	11	0.056-2.3	0.43	0.70	0.73	0.050	0.060	DL-0.10

* - From Ebasco, 1986b.
DL - The indicator level is the detection limit for UBTL and CAL Laboratories, as appropriate
N - Number of samples analyzed
1/ - Number of samples in which constituent was detected
2/ - Median, mean, and standard deviation not calculated when constituent detected in fewer than five samples
3/ - Volatiles were analyzed only in three samples of Boring 6

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the concept design basis, as it serves as a guide to the concentrations of chemicals that disposal facility barriers must withstand.

The contaminated soils at RMA generally have low target analyte levels, except for the relatively small quantities of heavily contaminated or agent-contaminated materials (Ebasco, 1985; ESE, 1987c). Analyte levels as high as 4,000 parts per million (ppm) of aldrin and dicyclopentadiene, 3,000 ppm of isodrin, 2,300 ppm of copper, 2,000 ppm of dieldrin, 1,000 ppm of toluene, and 900 ppm of endrin are found in soils underlying the Basin F liner (ESE, 1987c). Those materials may require treatment before land disposal if they are found to be banned wastes and if variance approval is not likely due to questions of analyte toxicity and persistence. While Task 27 will not determine the treatment for Basin F materials and heavily contaminated soils, the hazardous waste land disposal facility design assumes they will be treated to a condition acceptable for land disposal. Therefore, all RMA potentially contaminated materials are assumed to be wastes that have not been banned for land disposal, whether by treatment processes applied to heavily contaminated materials or low target analyte levels in the lightly contaminated materials.

I.6.2 Waste-to-Waste Compatibility

An important consideration in disposing of RMA wastes is the chemical compatibilities of the potentially contaminated materials. Some of these wastes may have chemical incompatibilities that will require segregation in the land disposal facility; chemical compatibility assessment is a determination of which wastes can be disposed of together. This assessment is required to avoid the commingling of wastes that may create uncontrolled problems of fire, explosion, toxic gas generation, and heat production.

More than 60 selected hazardous materials and chemicals of concern due to toxicity, persistence, or migration are known to be present in RMA soils and are presented in Table I-6 by name and chemical reactivity group, chemical surety agents, and suspected and known carcinogens are identified (G&M, 1984; Hatayama, 1980). Actual waste chemical composition will vary with excavation or treatment technology, and with soil PPLVs that may be used as criteria for the cleanup of RMA.

TABLE I-5

MEASURED CONTAMINANTS AT RMA a/

	Number of Chemical	Chemical	Number of Hits	Samples	Frequency (Percent)	Hits Concentrations (ppm) Average±σ b/
1.	ALDRN	ALDRIN	94	2,559	3.7	104±520
2.	AS	ARSENIC	524	2,604	20.1	148±2327
3.	ATZ	ATRAZINE	7	2,574	0.3	0.8±0.6
4.	BCHPD	BICYCLOHEPTADIENE	13	1,048	1.2	3.6±5.4
5.	CCL4	CARBON TETRACHLORIDE	2	970	0.2	0.3
6.	CD	CADMIUM	169	2,520	6.7	13.2±146
7.	CHCL3	CHLOROFORM	16	970	1.7	2.9±2.6
8.	CH2CL2	METHYLENE CHLORIDE	82	827	9.9	4.2±10.5
9.	CLC6H5	CHLOROBENZENE	5	971	0.5	2.4±2.0
10.	CLDAN	CHLORDANE	22	2,555	0.9	26.2±28.2
11.	CL6CP	HEXACHLOROCYCLOPENTADIENE	11	2,568	0.4	15.5±28.9
12.	CPMS	P-CHLOROPHENYLMETHYL SULFIDE	11	2,563	0.4	121±230
13.	CPMSO	P-CHLOROPHENYLMETHYL SULFOXIDE	17	2,563	0.7	7.5±16
14.	CPMSO2	P-CHLOROPHENYLMETHYL SULFONE	42	2,573	1.6	17.8±49
15.	CR	CHROMIUM	1,661	2,521	65.9	13.7±6.7
16.	CU	COPPER	2,145	2,521	85.1	16.8±53.6
17.	C6H6	BENZENE	21	1,053	2.0	5.4±6.7
18.	DCPD	DICYCLOPENTADIENE - Semivolatile	19	2,447	.8	119.85±456.0
19.	DDVP	VAPONA	1	2,576	0.09	3.0
20.	DIMP	DIISOPROPYLMETHYL PHOSPHONATE	34	2,563	1.3	3.2±2.6
21.	DITH	DITHIANE	5	2,545	0.2	3.7±4.5
22.	DLDRN	DIELDRIN	223	2,557	8.7	23.3±146.4
23.	DMDS	DIMETHYLDISULFIDE	3	1,039	0.2	4.3±5.0
24.	ENDRN	ENDRIN	31	2,567	1.2	55.5±165
25.	ETC6H5	ETHYLBENZENE	11	1,044	1.0	2.1±2.9
26.	HG	MERCURY	369	2,595	14.2	0.3±0.7
27.	ISODR	ISODRIN	45	2,562	1.8	86.2±447
28.	MEC6H5	TOLUENE	12	1,039	1.3	1.7±2.2
29.	MIBK	METHYLISOBUTYLKETONE	12	969	1.24	2.3±3.6
30.	MLTHN	MALATHION	2	2,567	0.08	0.5±0.3

TABLE I-5 (Continued)

MEASURED CONTAMINANTS AT RMA

	Chemical	Number of Hits	Number of Samples	Frequency (Percent)	Hits Concentrations (ppm) Averageî@
31. OXAT	1,4-OXATHIANE	1	2,549	0.04	6.0
32. PB	LEAD	768	2,518	30.5	28.3î52.3
33. PPDDE	DICHLORODIPHENYLETHANE	23	2,573	0.9	3.6î4.6
34. PPDDT	DICHLORODIPHENYLTRICHLOROETHANE	18	2,564	0.7	7.1î7.0
35. PRTHN	PARATHION	2	2,539	0.08	0.9
36. SUPONA	2-CHLORO-1(2,4-DICHLOROPHENYL) VINYLDIETHYL PHOSPHATE	4	2,570	0.15	5.8î9.5
37. PCA	TETRACHLOROETHANE	20	967	2.1	3.5î6.2
38. TCE	TRICHLOROETHLENE	1	967	0.1	0.3
39. T12DCE	TRANS-1,2-DICHLOROETHENE	1	586	0.2	0.3
40. XYLEN	ORTHO- AND PARA-XYLENE	12	1,047	1.1	6.1î8.0
41. ZN	ZINC	2,374	2,519	94.2	47î32
42. 11DCLE	1,1-DICHLOROETHANE	1	1,048	0.09	0.9
43. 111TCA	1,1,1-TRICHLOROETHANE	5	971	0.5	1.2î1.2
44. 112TCA	1,1,2-TRICHLOROETHANE	1	1,049	0.09	0.3
45. 12DCLE	1,2-DICHLOROETHANE	4	1,048	0.4	1î0.7
46. 13DMB	M-XYLENE	15	1,046	1.4	1.9î2.5
47. DMMP	DIMETHYL METHYL PHOSPHATE	6	1,086	0.6	18.7î26
48. 12DCE	1,2 DICHLOROETHENE	3	294	1.02	6.6î3.3
49. DBCP	DIBROMOCHLOROPROPANE	61	2,318	2.6	.14î.44

a/ The data presented is from a data base query conducted on 7/17/86 from RMA Task 35.
b/ @ is the standard deviation.

Given the diversity of waste types and contamination levels, an assessment of hazardous materials compatibilities is important in the design of the land disposal facility. A compatibility chart for chemical reactivity groups is shown in Table I-7 (Hatayama, 1980). This chart shows that strong oxidizing and reducing agents are incompatible with all other chemical reactivity groups common to RMA wastes, suggesting the necessity of segregation or treatments of certain wastes before disposal. An example is treatments of hydrazine compounds, which are presently receiving separate attention as part of the hydrazine blending and storage facility decommissioning efforts under Task 34 (Ebasco 1987). Another important chemical reactivity group is explosives. Explosive materials will be handled separately from other waste to ensure demilitarization of unexploded ordnance. In addition, potentially agent-contaminated materials will likely require treatment to be landfilled (DALF, 1984). Another aspect of waste-to-waste incompatibility is the biodegradation product methane, common to putrescible organic materials such as paper or wood. While only minor quantities of putrescible organic materials are expected, the design will provide for gas venting.

Many RMA contaminated materials have chemical constituents that fall into eight chemical reactivity groups: 9, 16, 17, 19, 20, 24, 27, and 32. These reactivity groups appear compatible with one another so that disposal of these contaminated materials in the same waste cell is acceptable.

Many of the contaminated materials at RMA are lightly contaminated soils with low concentrations of various chemicals. Reactivity is often low at dilute concentrations of reagents, since the chemical reagents are dispersed and immobilized in the soil matrix by adsorption or absorption. Waste-to-waste incompatibility should not be a particular problem of these lightly contaminated soils.

I.6.3 Waste-to-Barrier Interactions

The compatibility of the waste cell barrier with the specific wastes is a major consideration in planning and designing a land disposal facility. The design of a lined waste cell must take into account which available liner (barrier) materials will not be degraded by the wastes. Since liquids will

TABLE I-6

SELECTED HAZARDOUS MATERIALS AND CHEMICAL CONSTITUENTS OF ROCKY MOUNTAIN ARSENAL WASTES

Name	Reactivity Group Numbers
ORGANIC CHEMICALS:	
ALIPHATIC AND AROMATIC AMINES	7
*N-Nitrosodimethylamine (DMNA)	7, 27
Atrazine	7
AZO COMPOUNDS, DIAZO COMPOUNDS AND HYDRAZINE	8
Benzothiazole	8, 102
Monomethyl hydrazine	8
Hydrazine	8
Unsymmetrical Dimethyl hydrazine (UDMH)	8
AROMATIC HYDROCARBONS	16
*Benzene	16
Bicycloheptadiene	16
Ethylbenzene	16
Toluene	16
Xylene	16
HALOGENATED ORGANICS	17
**Aldrin	17
**Carbon Tetrachloride	17
Chlordane	17
Chlorobenzene	17
**Chloroform	17
P-Chlorophenylmethylsulfide (CPMS)	17
P-Chlorophenylmethylsulfone ($CPMSO_2$)	17
P-Chlorophenylmethylsulfoxide (CPMSO)	17
DDE (P,P' Dichlorodiphenyldichloroethlyene)	17
**DDT (Dichlorodiphenyltrichloroethane)	17
1,1 Dichloroethane	17
1,2 Dichloroethane	17
1,1 Dichloroethylene	17
1,2 Dichloroethylene	17
Dicyclopentadiene	17
Dieldrin	17
Endrin	17
Hexachlorocyclopentadiene (HCCPD)	17
Isodrin	17
Methylene Chloride	17

TABLE I-6 (Continued)

SELECTED HAZARDOUS MATERIALS AND CHEMICAL CONSTITUENTS OF ROCKY MOUNTAIN ARSENAL WASTES

Name	Reactivity Group Numbers
ORGANIC CHEMICALS:	
HALOGENATED ORGANICS (Continued)	
**Polychlorinated Biphenyl (PCB)	17
Tetrachloroethylene	17
1,1,1 Trichloroethane	17
1,1,2 Trichloroethane	17
**Trichloroethylene	17
KETONES	19
Methyl Isobutyl Ketone (MIBK)	19
MERCAPTANS AND OTHER SULFIDES	20
Dimethyl Disulfide	20
NITRO COMPOUNDS, ORGANIC	27
ALIPHATIC AND UNSATURATED HYDROCARBONS	28
ORGANO PHOSPHATES, PHOSPHOTHIOATES AND PHOSPHODITHIOATES	32
Azodrin	32
Malathion	32
Parathion	32
Vapona	32
EXPLOSIVES	102
AGENT MATERIALS AND DEGRADATION PRODUCTS	N/A
Diisopropylmethylphosphonate (DIMP)	N/A
Dimethyl methyl phosphonate (DMMP)	N/A
Dithiane (DITH)	N/A
GB (Sarin)	N/A
Isopropyl methyl phosphonate (IMP)	N/A
Lewisite (B-Chlorovinyl dichloroarsine)	N/A
Lewisite Oxide (B-Chlorovinyl-dichloroarsine epoxide)	N/A
*Mustard (B,B'-Dichlorodiethylsulfide)	N/A
Thiodiglycol	N/A
Thioxane (OXAT)	N/A

N/A Not Available

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TABLE I-6 (Continued)

SELECTED HAZARDOUS MATERIALS AND CHEMICAL CONSTITUENTS OF ROCKY MOUNTAIN ARSENAL WASTES

Name	Reactivity Group Numbers
INORGANIC CHEMICALS:	
*Arsenic	24
Bromine	104
*Asbestos	---
ALKALI-EARTH METALS	
Calcium Salts	---
Magnesium Salts	---
Potassium Salts	---
Sodium Salts	---
Phosphorous (White)	105
HEAVY METALS	
**Cadmium	24
*Chromium	24
Copper	24
**Lead	24
Mercury	24
Zinc	24
ANIONS	
Bromide	---
Chloride	---
Chlorate	---
Fluoride	---
Phosphate	---
Sulfate	---

NOTES:

* Carcinogen
** Suspected carcinogen

TABLE I-7 HAZARDOUS MATERIALS COMPATIBILITY CHART*

Reactivity Group Number	Reactivity Group Name													
7	Aliphatic and Aromatic Amines	7												
8	Azo Compounds, Diazo Compounds and Hydrazine	--	8											
9	Carbamates	--	G H	9										
16	Aromatic Hydrocarbons	--	--	--	16									
17	Halogenated Organics	H GT	H G	--	--	17								
19	Ketones	--	H G	--	--	--	19							
20	Mercaptans and Other Sulfides	--	H G	--	--	H	H	20						
24	Metals and Metal Compounds Toxic	S	--	--	--	--	--	--	24					
27	Nitro Compounds, Organic Hydrocarbons	--	--	--	--	--	--	--	--	27				
32	Organophosphates, Phosphotioates and Phosphodithioates	--	U	--	--	--	--	--	--	--	32			
102	Explosives	--	H E	--	--	--	--	E	--	--	--	102		
104	Strong Oxidizing Agents	H, F GT	H G	H, F GT	H F	H GT	H F	H, F GT	--	H E	H, F GT	H E	104	
105	Strong Reducing Agents	H GF	H G	--	--	H E	GF H	GF H	--	H E	GT GF,H	H E	H, F E	105

Legend:
H = Heat Generation
F = Fire
G = Innocuous and Nonflammable Gas Generation
GT = Toxic Gas Generation
S = Solubilization of Toxic Substances
U = May Be Hazardous but Unknown
GF = Flammable Gas Generation
E = Explosion

* From Hatayama, 1980.

not be placed in the waste cells, the possibility of undesirable chemical reactions will be reduced.

The U.S. EPA guidance documents and hazardous waste regulations (40 CFR 264) prescribe that a hazardous waste land disposal facility, complying with RCRA, shall have a double-barrier system. The double barrier is one flexible membrane liner with one clay liner, or a composite of flexible membrane liner and clay liner (EPA, 1985). Since the flexible membrane liner would be the first barrier to contact the RMA wastes, its compatibility with the waste is of key importance in the concept design.

A review of the extensive literature on flexible membrane liners was done by A.D. Little, Inc. (1985a). Fourteen of the more than 60 target analytes found at RMA were examined in that review for 23 liners. The high-density polyethylene liner appeared to be the most resistant to the RMA chemicals. Further discussion of barrier-to-waste compatibility is presented in Section 6.

Since the waste characterization data identified chemical compounds not tested for by liner manufacturers, final liner selection should be based on actual compatibility testing.

I.7 PHYSICAL PROPERTIES OF WASTES

No liquid wastes will be allowed in the land disposal facility. The characteristics of the soil and building debris wastes are briefly summarized in this section.

I.7.1 Soil

Four major soil associations are found at the RMA. These include the Alluvial Land, Ascalon-Vona-Truckton, Blakeland-Valent-Terry, and Platner-Ulm-Renohill Associations (G&M, 1984). Of these associations, the Ascalon-Vona-Truckton and Platner-Ulm-Renohill are representative of more than 80 percent of the near-surface soils of RMA (Sampson & Baber, 1974; G&M, 1984). The Ascalon-Vona-Truckton Association is nearly level to strongly sloping, well drained to somewhat excessively drained, and loamy and sandy soil formed in wind-laid deposits on uplands (Sampson & Baber, 1974). The Platner-Ulm-Renohill Association is a nearly level to strongly sloping, well drained loamy soil formed in old alluvium on interbedded shale and sandstone on uplands (Sampson & Baber, 1974).

Since much of the contaminated materials at RMA are surface soils, the estimated physical properties from the Adams County soil survey (Sampson & Baber, 1974) provides reasonable conceptual design parameters for the contaminated soils. These characteristics of RMA soils are discussed at length in Chapters 4 and 7.

The contaminated soil materials include clays, sands, and silts. Soil physical properties of interest include density, moisture content, ease of transportation and stockpiling, and drying characteristics. These are assumed to be typical for the soil types indicated. The excavated contaminated soils will be assumed to be handled and transported by standard heavy equipment with appropriate personnel safety equipment. The fine component of the materials when dry could be subject to wind transport and will require efforts to minimize this effect (Sampson & Baber, 1974). A volume expansion factor of 1.15 and compaction factor of 0.95 as applied to the bank volume estimate will be used based on literature values (Caterpillar, 1981).

I.7.2 Buildings and Debris

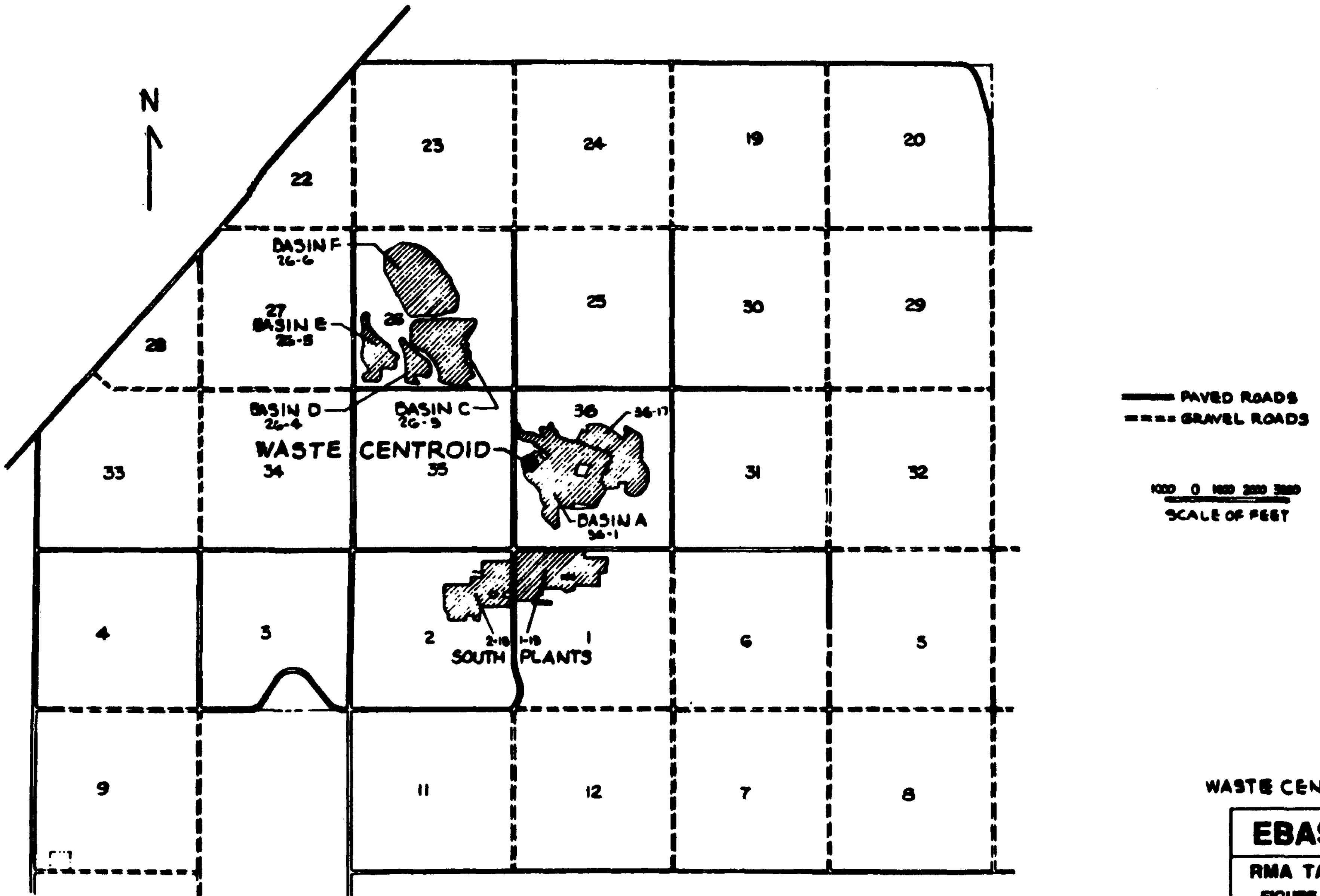
The building debris will consist of broken concrete of various sizes, masonry, wood, steel sheets, and miscellaneous steel. The equipment consists of pumps, piping, motors, and other utilities. Much of the material has a high piercing ability and, therefore, must be isolated from any liners in the land disposal facility. The DALF addresses the disposal of this material, either with the relatively large quantity of soil materials or in a separate facility specifically designed for this type of waste. The procedure would be to incorporate the contaminated building debris in the center of the waste cells of the land disposal facility so that it would occupy only a few percent of the volume of any given cell. Materials will be placed in such a manner that voids will be filled between pieces to preclude settlement.

I.8 WASTE LOCATIONS

The closer the disposal site is to the centroid of contaminated materials (waste centroid), the lower the hauling costs and environmental impacts from heavy vehicle operations. Forty sites, each over 20,000 bcy and totalling more than 90 percent of the contaminated materials, were used as a basis for the waste centroid determination. The waste centroid was determined to be very close to the Basin A neck area in Section 36, as shown in Figure I-1. Five major contaminated sites are located near the waste centroid. These sites include the South Plants (1-13 and 2-18), Basin A (36-1), Basin C (26-3), and Basin F (26-6). The waste centroid and major sites are also located near the paved roadway system. The location of a disposal site in close proximity to paved roads and the waste centroid reduces the waste transportation costs and environmental impact of the disposal site location as discussed in Chapter 3.

I.9 SUMMARY

The estimated design volume of potentially contaminated material was based on the review of past and ongoing studies is about 13.3 million bcy, 16.5 million lcy, and 14.1 million ccy. A comprehensive comparison of volumes by section is provided in Table I-2 and by individual site in Attachment A. This total volume includes approximately 65,000 cy of contaminated building debris and approximately 7,000 cy of unexploded ordnance, with the remaining major volume consisting of toxic and hazardous material or chemical surety contaminated soils. The volume estimates were generally based on estimated areal extents of contamination multiplied by estimated depth of excavation required to effectively remove the contaminated material. The estimates were derived from the DALF and Ebasco and ESE Remedial Investigations data. These sources characterize the potentially contaminated materials as all material at or above target analyte indicator levels, which are the detection thresholds or background levels. Expansion and compaction estimates were based on literature values and engineering judgment.



WASTE CENTROID

EBASCO

RMA TASK 27

FIGURE I-1

The analysis found two basic waste forms, building debris and excavated soil. These waste forms include the following waste volumes: 65,000 of contaminated buildings debris, and 13.3 million bcy excavated soil, of which at least 1.4 million bcy is estimated to be heavily contaminated soil, as of February 6, 1987.

The chemical properties of the RMA wastes indicate that most can be disposed of together and chemical contaminant levels may range from 0.1 to 4,000 ppm average level for a given analyte as shown in Tables I-3 and I-4. It appears from preliminary analysis that limited potential exists for fire and explosion from untreated RMA wastes.

The physical properties of most RMA wastes will be those of soils from the Ascalon-Vona-Truckton and Platner-Ulm-Renohill Associations.

The potentially contaminated materials are located at more than 100 sites on the RMA. The waste centroid is near five major potentially contaminated RMA sites and the Basin A neck area. A proposed disposal site nearest to this waste centroid will have the least waste haul costs and environmental impacts from heavy vehicle operations.

APPENDIX I

ATTACHMENT A

TABLES

TABLE A-1

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF,RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type1/	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO2/	Volume of Surety	Degree of Confidence
1	1-1	J	115,200	10	43,000	--	43,000	43,000	--	--	Moderate
	1-23/	--	--	--	--	--	--	--	--	--	--
	1-5	A	96,000	15	53,000	--	53,000	53,000	--	--	Moderate
	1-7	F	691,200	3	77,000	--	77,000	77,000	--	--	Moderate
	1-8	F	294,400	3	33,000	--	33,000	33,000	--	--	Moderate
	1-10	L	473,600	10	175,000	--	175,000	175,000	--	--	Low
	1-12	I	120,000	10	44,000	--	44,000	44,000	--	--	Low
	1-13	L	3,840,000	12.5	1,778,000	--	1,778,000	1,600,200	--	177,800	Low
	Buildings4/	M	198,200	NA	--	23,400	23,400	--	--	23,400	Low
SUBTOTAL			5,828,600		2,203,000	23,400	2,226,400	2,025,200	0	201,200	
2	2-1	J	177,600	10	66,000	--	66,000	66,000	--	--	High
	2-2	E	128,000	2	1,000	--	1,000	991	9	--	Moderate
	2-3	A	32,000	15	18,000	--	18,000	18,000	--	--	Moderate
	2-6	A	38,400	15	21,000	--	21,000	21,000	--	--	Moderate
	2-7	A	25,600	15	14,000	--	14,000	14,000	--	--	Moderate
	2-14	I	198,400	10	73,000	--	73,000	73,000	--	--	Moderate
	2-17	H	3,142,000	2	233,000	--	233,000	233,000	--	--	Low
	2-18	L	2,822,000	12.5	1,307,000	--	1,307,000	1,176,300	--	130,700	Low
	Buildings5/	M	111,700	NA	--	12,310	12,310	--	--	12,310	Moderate
SUBTOTAL			6,675,700		1,733,000	12,310	1,745,310	1,602,291	9	143,010	
3	3-2	J	3,480	10	1,000	--	1,000	1,000	--	--	Moderate
	3-3	A	27,000	15	15,000	--	15,000	15,000	--	--	Moderate
	3-4	L	28,800	15	16,000	--	16,000	16,000	--	--	Low
SUBTOTAL			59,280		32,000	0	32,000	32,000	0	0	

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TABLE A-1 (Continued)

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type[1/]	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO[2/]	Volume of Surety	Degree of Confidence
4	4-2	D	154,000	10	57,000	--	57,000	57,000	--	--	Low
	4-3	D	183,000	10	68,000	--	68,000	68,000	--	--	Low
	4-4	D	672,000	10	249,000	--	249,000	249,000	--	--	Low
SUBTOTAL			1,009,000		374,000	0	374,000	374,000	0	0	
5	5-2	L	1,324,000	3	147,000	--	147,000	--	--	147,000	Low
SUBTOTAL			1,324,000		147,000	0	147,000	0	0	147,000	
6	6-2[6/]	--	--	--	--	--	--	--	--	--	--
	6-5	L	9,600	3	1,000	--	1,000	--	--	1,000	Low
	6-6	F	867,000	3	96,000	--	96,000	--	--	96,000	Moderate
SUBTOTAL			876,600		97,000	0	97,000	0	0	97,000	
11	11-1	C	339,000	NA	53,000	--	53,000	53,000	--	--	High
SUBTOTAL			339,000		53,000	0	53,000	53,000	0	0	
12	12-1	C	356,000	NA	55,000	--	55,000	55,000	--	--	High
	12-2	H	858,000	2	64,000	--	64,000	64,000	--	--	Moderate
SUBTOTAL			1,214,000		119,000	0	119,000	119,000	0	0	

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TABLE A-1 (Continued)

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type[1/]	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO[2/]	Volume of Surety	Degree of Confidence
19	19-1	E	102,000	2	1,000	--	1,000	992	8	--	Moderate
SUBTOTAL			102,000		1,000	0	1,000	992	8	0	
20	20-1	E	102,000	2	1,000	--	1,000	992	8	--	Moderate
SUBTOTAL			102,000		1,000	0	1,000	992	8	0	
24	24-5[6/]	--	--	--	--	--	--	--	--	--	--
	24-6	A/M	172,000	15	96,000	--	96,000	96,000	--	--	Low
SUBTOTAL			172,000		96,000	0	96,000	96,000	0	0	Low
25	25-2	G	10,800	15	6,000	--	6,000	6,000	--	--	Moderate
	25-3	G	21,000	15	12,000	--	12,000	12,000	--	--	Moderate
	25-4	M	79,430	NA	--	3,270	3,270	--	--	3,270	Low
	25-5	M	5,000	NA	--	670	670	--	--	670	Low
	25-6	M	120	NA	--	200	200	--	--	200	Low
	25-7	M	2,800	NA	--	1,890	1,890	--	--	1,890	Low
	25-8	M	74,910	NA	--	8,600	8,600	--	--	8,600	Low
	25-9	M	7,500	NA	--	870	870	--	--	870	Low
	25-10	M	61,200	NA	--	7,500	7,500	--	--	7,500	Low
	25-11	M	8,460	NA	--	1,000	1,000	--	--	1,000	Low
	25-12	M	9,000	NA	--	1,100	1,100	--	--	1,100	Low
	25-13	M	4,000	NA	--	500	500	--	--	500	Low
	25-14	M	30,600	NA	--	3,600	3,600	--	--	3,600	Low
	25-15	M	900	NA	--	100	100	--	--	100	Low
SUBTOTAL			315,720		18,000	29,300	47,300	18,000	0	29,300	

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TABLE A-1 (Continued)

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type[1/]	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO[2/]	Volume of Surety	Degree of Confidence
26	26-3	A	3,174,000	15	1,763,000	--	1,763,000	1,763,000	--	--	Moderate
	26-4	A	877,000	15	487,000	--	487,000	487,000	--	--	Moderate
	26-5	A	1,280,000	15	711,000	--	711,000	711,000	--	--	Moderate
	26-6	B/G	4,051,000	6	1,360,000 [7/]	--	1,360,000	1,360,000	--	--	Moderate
	26-7	J	1,000	10	1,000	--	1,000	1,000	--	--	Moderate
SUBTOTAL			9,383,000		4,322,000	0	4,322,000	4,322,000	0	0	
29	29-1	E	102,000	2	1,000	--	1,000	992	8	--	Moderate
	29-4	C	2,601,000	15	217,000	--	217,000	215,555	1,445	--	Low
	29-5	C	434,000	15	36,000	--	36,000	35,759	241	--	Low
SUBTOTAL			3,137,000		254,000	0	254,000	252,306	1,694	0	
30	30-1	K	7,219,000	6	241,000	--	241,000	239,396	1,604	--	Low
	30-2	E	102,000	2	1,000	--	1,000	992	8	--	Moderate
	30-3	E	43,700	2	3,000	--	3,000	--	--	3,000	Moderate
	30-4	I	208,000	10	77,000	--	77,000	77,000	--	--	Low
	30-6	C	153,000	15	85,000	--	85,000	--	--	85,000	Low
SUBTOTAL			7,725,700		407,000	0	407,000	317,388	1,612	88,000	
31	31-2	L	13,500	3	2,000	--	2,000	--	--	2,000	Moderate
	31-4	F	351,000	3	39,000	--	39,000	--	--	39,000	Moderate
	31-6	F	707,000	3	79,000	--	79,000	--	--	79,000	Moderate
	31-7	F	437,000	3	49,000	--	49,000	--	--	49,000	Moderate
SUBTOTAL			1,508,500		169,000	0	169,000	0	0	169,000	

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TABLE A-1 (Continued)

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type[1/]	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO[2/]	Volume of Surety	Degree of Confidence
32	32-1	C	94,000	15	8,000	--	8,000	7,948	52	--	Moderate
	32-5	D	166,000	10	61,000	--	61,000	60,939	61	--	Moderate
	32-6	D	213,000	10	79,000	--	79,000	78,921	79	--	Moderate
SUBTOTAL			473,000		148,000	0	148,000	147,808	192	0	
35	35-1[6/]	--	--	--	--	--	--	--	--	--	--
	35-2[8/]	--	--	--	--	--	--	--	--	--	--
	35-3	A	77,000	15	43,000	--	43,000	43,000	--	--	Moderate
	35-4	J	12,600	10	5,000	--	5,000	5,000	--	--	Moderate
	35-6	E	96,000	2	1,000	--	1,000	993	7	--	Moderate
	35-7	K	2,061,000	6	69,000	--	69,000	68,542	458	--	Low
SUBTOTAL			2,246,600		118,000	0	118,000	117,535	465	0	
36[9/]	36-1	A	5,369,000	10	2,289,000	--	2,289,000	200,000 [10/]	--	2,089,000	Moderate
	36-2	E	1,171,000	2	13,000	--	13,000	12,913	87	--	Moderate
	36-3	C	61,000	10	23,000	--	23,000	23,000	--	--	Moderate
	36-4	A	130,000	10	48,000	--	48,000	48,000	--	--	Moderate
	36-5	L	27,000	10	1,000	--	1,000	1,000	--	--	Low
	36-6	E	147,000	2	2,000	--	2,000	2,000	--	--	Low
	36-7	I	617,000	10	229,000	--	229,000	229,000	--	--	Moderate
	36-8	J	22,200	10	8,000	--	8,000	8,000	--	--	Moderate
	36-9	E	152,000	2	2,000	--	2,000	1,989	11	--	Moderate
	36-10	C	173,000	10	64,000	--	64,000	64,000	--	--	Moderate
	36-11	A	102,000	10	38,000	--	38,000	38,000	--	--	Moderate
	36-12	C	120,000	10	44,000	--	44,000	44,000	--	--	Moderate
	36-13	C	18,000	10	7,000	--	7,000	7,000	--	--	Moderate
	36-14	C	58,000	10	21,000	--	21,000	--	--	21,000	Moderate
	36-15	D	128,000	10	7,000	--	7,000	6,953	47	--	Moderate
	36-16	C	77,000	10	4,000	--	4,000	3,971	29	--	Moderate
	36-17	C	4,685,000	15	2,603,000	--	2,603,000	--	2,603	2,600,397	Low
	36-18	C	7,600	10	3,000	--	3,000	3,000	--	--	Low

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TABLE A-1 (Continued)

SECTION-BY-SECTION INITIAL MATERIAL HANDLING VOLUME ESTIMATES IN BANK CUBIC YARDS
(FROM DALF RMACCPMT, 1984/RIC 84034R01)

Section Number	Site ID No.	Type1/	Area (Sq Ft)	Depth of Excavation (Ft)	Volume of Excavation	Volume of Equipment and Buildings Demolition	Total Volume	Volume of Toxic and Hazardous	Volume of UXO2/	Volume of Surety	Degree of Confidence
	36-19	C	305,000	10	113,000	--	113,000	113,000	--	--	Moderate
	36-20	G	12,000	15	7,000	--	7,000	7,000	--	--	Moderate
SUBTOTAL			13,381,800		5,526,000	0	5,526,000	812,826	2,777	4,710,397	
TOTAL			55,873,695		15,818,000	65,010	15,883,010	10,291,338	6,765	5,584,907	

1/ Contaminated type classification described in Table A-1.
2/ UXO = Unexploded ordnance
3/ To be relocated into Site 36-1 under baseline actions.
4/ Includes contaminated buildings 412, 413, 422, 424, 425, 426, 427, 429, 431, 512, 514, 516, 521, 522, 523, 523A, 525, 528, 536, 537, 538, 541, and 742.
5/ Includes contaminated buildings 242, 243, 331, 343, 344, 345, and 346.
6/ To be relocated into Site 26-6 under baseline actions.
7/ Includes additional volume from baseline actions.
8/ Previously relocated into Site 26-6 under baseline actions.
9/ Due to shallow depth to groundwater, some sites have a limited depth of excavation.
10/ Includes additional volume from baseline actions.

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TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
1-1	43,000	--	58,000	7	58,000	66,700	55,100
1-2	--	--	NA*	12	NA*	NA*	NA*
1-3	--	--	2,460	2	2,500	2,900	2,400
1-4	--	--	CU	2	--	--	--
1-5	53,000	--	NA*	2	53,000	61,000	50,400
1-7	77,000	--	2,600***	11, 34	NA*	2,600***	2,100***
1-8	33,000	--	NA*	2	33,000	38,000	31,400
1-9	--	--	13,900	7	13,900	16,000	13,200
1-10	175,000	--	NA*	2	175,000	201,300	166,300
1-11	--	--	NA*	2	NA*	NA*	NA*
1-12	44,000	--	NA*	12	44,000	50,600	41,800
1-13	1,778,000	--	NA*	2	1,778,000	2,044,700	1,689,100
Buildings	23,400	--	NA*	24	23,400	35,100	28,100
UNC-1*	--	--	NA*	7	NA*	NA*	NA*
Subtotal	2,226,400	--	76,960		2,180,800	2,518,900	2,079,900
2-1	66,000	--	NA*	7	66,000	75,900	62,700
2-2	1,000	--	NA*	2	1,000	1,200	1,000
2-3	18,000	--	13,700	2	13,700	15,800	13,000
2-4	--	--	CU*	2	--	--	--
2-5	--	--	NA*	2	NA*	NA*	NA*
2-6	21,000	--	NA*	2	21,000	24,200	20,000
2-7	14,000	--	1,100	2	1,100	1,300	1,000
2-8	--	--	NA*	2	NA*	NA*	NA*
2-9	--	--	39,000	2	39,000	44,900	37,100
2-12	--	--	2,100	2	2,100	2,400	2,000
2-13	--	--	CU*	2	--	--	--
2-14	73,000	--	19,800	2	19,800	22,800	18,800
2-17	233,000	--	NA*	2	233,000	268,000	221,400
2-18	1,307,000	--	NA*	2	1,307,000	1,503,100	1,241,700
Buildings	12,310	--	NA*	24	12,300	18,500	14,800
UNC-2*		--	NA*	7	NA*	NA*	NA*
Subtotal	1,745,310	--	55,900		1,716,000	1,978,100	1,633,500

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.
***Loose cubic yards of building debris from Ebasco (1987c). Soil volume estimate not available as of 2/6/87.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
3-1	--	--	NA*	10	NA*	NA*	NA*
3-2	1,000	--	***	7	--	--	--
3-3	15,000	--	31,000	7	31,000	35,700	29,500
3-4	16,000	--	16,800	7	16,800	19,300	16,000
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-3*	--	--	CU*	15	--	--	--
Subtotal	32,000	--	47,800		47,800	55,000	45,500
4-1	--	--	NA*	10	NA*	NA*	NA*
4-2	57,000	--	9,000	15	9,000	10,400	8,600
4-3	68,000	--	22,000	15	22,000	25,300	20,900
4-4	249,000	--	NA*	15	249,000	286,400	236,600
4-5	249,000	--	164,000	15	164,000	188,600	155,800
4-6	--	--	NA*	38	NA*	NA*	NA*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-4*	--	--	CU*	15	--	--	--
Subtotal	623,000	--	195,000		444,000	510,700	421,900
5-2	147,000	--	NA*	15	147,000	169,100	139,700
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-5*	--	--	CU*	15	--	--	--
Subtotal	147,000	--	--		147,000	169,100	139,700
6-2	--	--	NA*	12	NA*	NA*	NA*
6-5	1,000	--	NA*	15	1,000	1,200	1,000
6-6	96,000	--	NA*	15	96,000	110,400	91,200
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-6*	--	--	CU*	15	--	--	--
Subtotal	97,000	--	--		97,000	111,600	92,200

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.

**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.

***Site 3-2 is included in Site 3-3 (Ebasco, 1986p).

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
Buildings	--	--	CU*	24	--	--	--
UNC-7*	--	--	NA*	15	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
Buildings	--	--	CU*	24	--	--	--
UNC-8*	--	--	NA*	15	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
Buildings	--	--	CU*	24	--	--	--
UNC-9*	--	--	NA*	15	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
11-1	53,000	--	NA*	12	53,000	61,000	50,400
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-11*	--	--	CU*	15	--	--	--
Subtotal	53,000	--	--		53,000	61,000	50,400
12-1	55,000	--	180,000	12	180,000	207,000	171,000
12-2	64,000	--	NA*	12	64,000	73,600	60,800
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-12*	--	--	CU*	15	--	--	--
Subtotal	119,000	--	180,000		244,000	280,600	231,800

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Expanded (LCY)*	Disposal (CCY)*
19-1	1,000	NA*	--	14	1,000	1,200	1,000
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-19*	--	CU*	--	14	--	--	--
Subtotal	1,000	--	--		1,000	1,200	1,000
20-1	1,000	NA*	--	14	1,000	1,200	1,000
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-20*	--	NA*	--		NA*	NA*	NA*
Subtotal	1,000	--	--		1,000	1,200	1,000
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-22	--	NA*	--	14	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-23	--	NA*	--	14	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
24-5	--	--	NA*	10	NA*	NA*	NA*
24-6	96,000	--	NA*	7	96,000	110,400	91,200
24-7	--	--	CU*	7	--	--	--
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-24*	--	NA*	--	14	NA*	NA*	NA*
Subtotal	96,000	--	--		96,000	110,400	91,200

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Expanded (LCY)*	Disposal (CCY)*
25-2	6,000	--	NA*	10	6,000	6,900	5,700
25-3	12,000	--	NA*	10	12,000	13,800	11,400
25-4	***	--	***	24	***		
25-5	***	--	***	24	***		
25-6	***	--	***	24	***		
25-7	***	--	***	24	***		
25-8	***	--	***	24	***		
25-9	***	--	***	24	***		
25-10	***	--	***	24	***		
25-11	***	--	***	24	***		
25-12	***	--	***	24	***		
25-13	***	--	***	24	***		
25-14	***	--	***	24	***		
25-15	***	--	***	24	***		
25-16	--	--	--	42	--		
Buildings	29,300	--	NA*	24	29,300	44,000	35,200
UNC-25*	--	NA*	--	14	NA*	NA*	NA*
Subtotal	47,300	--	--		47,300	64,700	52,300
26-1	--	NA*	--	6	NA*	NA*	NA*
26-3	1,763,000	NA*	--	6	1,763,000	2,027,500	1,674,900
26-4	487,000	162,000	--	6	162,000	186,300	153,900
26-5	711,000	711,000	--	6	711,000	817,700	675,500
26-6	1,360,000	NA*	--	6	1,360,000	2,720,000	2,720,000
26-7	1,000	****	--	6	--	--	--
26-8	--	--	NA*	10	NA*	NA*	NA*
26-9	--	--	NA*	10	NA*	NA*	NA*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-26*	--	NA*	--	6	NA*	NA*	NA*
Subtotal	4,322,000	873,000	--		3,996,000	5,751,500	5,224,300

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.
***Building Sites are summarized under buildings for this section.
****Site 26-7 Basin B and C Drainage included with Site 35-4.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-27*	--	CU*	--	14	--	--	--
Subtotal	--	--	--		--	--	--
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-28*	--	NA*	--	14	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
29-1	1,000	3,200	--	14	3,200	3,700	3,000
29-4	217,000	31,000	--	14	31,000	35,700	29,500
29-5	36,000	CU*	--	14	--	--	--
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-29*	--	CU*	--	14	--	--	--
Subtotal	254,000	34,200	--		34,200	39,400	32,500
30-1	241,000	68,000***	--	14	68,000	78,200	64,600
30-2	1,000	2,300	--	14	2,300	2,600	2,200
30-3	3,000	3,000	--	14	3,000	3,500	2,900
30-4	77,000	--	NA*	7	77,000	88,600	73,200
30-5	--	CU*	--	14	--	--	--
30-6	85,000	13,300	--	14	13,300	15,300	12,600
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-30*	--	NA*	--	14	NA*	NA*	NA*
Subtotal	407,000	86,600	--		163,600	188,200	155,500

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.
***67,500 bcy hazardous waste and 450 bcy UXO (ESE, 1986q).

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Expanded (LCY)*	Disposal (CCY)*
31-2	2,000	--	NA*	15	2,000	2,300	1,900
31-4	39,000	--	NA*	15	39,000	44,900	37,100
31-6	79,000	--	NA*	15	79,000	90,900	75,100
31-7	49,000	--	NA*	15	49,000	56,400	46,600
31-8	--	--	NA*	15	NA*	NA*	NA*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-31*	--	--	CU*	15	--	--	--
Subtotal	169,000	--	--		169,000	194,500	160,700
32-1	8,000	***	--	14	--	--	--
32-5	61,000	--	NA*	15	61,000	70,200	58,000
32-6	79,000	--	NA*	15	79,000	90,900	75,100
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-32*	--	--	NA*	15	NA*	NA*	NA*
Subtotal	148,000	--	--		140,000	161,100	133,100
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-33*	--	--	CU*	15	--	--	--
Subtotal	--	--	--		--	--	--

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
**Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.
***Site 32-1 volume estimate incorporated into Site 29-5.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
34-2	--	--	NA	10	NA*	NA*	NA*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-34*	--	NA*	--	14	NA*	NA*	NA*
Subtotal	--	--	--		NA*	NA*	NA*
35-1	--	--	NA*	10	NA*	NA*	NA*
35-2	--	--	NA*	10	NA*	NA*	NA*
35-3	43,000	43,000	--	6	43,000	49,500	40,900
35-4	5,000	10,000***	--	6	10,000	11,500	9,500
35-6	1,000	CU*	--	14	--	--	--
35-7	69,000	NA*	--	14	69,000	79,400	65,600
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-35*	--	CU*	--	6	--	--	--
Subtotal	118,000	53,000	--		122,000	140,400	116,000

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
** Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.
***Site 35-4 included with Site 26-7.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
36-1	2,289,000	585,000	--	1	585,000	672,800	555,800
36-2	13,000	NA*	--	14	13,000	15,000	12,400
36-3	23,000	NA*	--	1	23,000	26,500	21,900
36-4	48,000	82,000	--	1	82,000	94,300	77,900
36-5	1,000	NA*	--	1	1,000	1,200	1,000
36-6	2,000	6,200	--	14	6,200	7,100	5,900
36-7	229,000	26,000	--	1	26,000	29,900	24,700
36-8	8,000	12,000	--	1	12,000	13,800	11,400
36-9	2,000	NA*	--	14	2,000	2,700	1,900
36-10	64,000	NA*	--	1	64,000	73,600	60,800
36-11	38,000	15,500	--	1	15,500	17,800	14,700
36-12	44,000	NA*	--	1	44,000	50,600	41,800
36-13	7,000	NA*	--	14	7,000	8,100	6,700
36-14	21,000	NA*	--	14	21,000	24,200	20,000
36-15	7,000	4,000	--	1	4,000	4,600	3,800
36-16	4,000	NA*	--	14	4,000	4,600	3,800
36-17	2,603,000	NA***	--	1	2,603,000	2,993,500	2,472,900
36-18	3,000	CU*	--	14	--	--	--
36-19	113,000	NA*	--	14	113,000	130,000	107,400
36-20	7,000	6,000	--	1	6,000	6,900	5,700
36-21	--	1,200	--	1	1,200	1,400	1,100
36-22	--	NA*	--	1	NA*	NA*	NA*
36-23	--	NA*	--	1	NA*	NA*	NA*
Buildings	--	--	NA*	24	NA*	NA*	NA*
UNC-36*	--	NA*	--	1	NA*	NA*	NA*
Subtotal	5,526,000	737,900	--		3,632,900	4,178,200	3,451,600

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.

** Volume Estimates rounded to nearest 100 bcy based on current RI/FS studies or the DALF.

***Site 36-17 volume estimate not available as of 2/6/87, however, surety contaminated material may be present at this site.

TABLE A-2
SUMMARY OF POTENTIALLY CONTAMINATED MATERIALS BY SITE

Site ID	DALF Total Volume (BCY)*	ESE Tasks Update 1, 6, 14, 21 (BCY)*	Ebasco Tasks Update 2,7,10,11, 12,15,17,24,or 34 (BCY)*	RMA Task Number	Volume Estimates** Expected (BCY)*	Volume Estimates** Expanded (LCY)*	Volume Estimates** Disposal (CCY)*
South Plants Regional	--	--	NA*	2	NA*	NA*	NA*
Spill Sites	--	--	NA*	24	NA*	NA*	NA*
Subtotal	--	--	--		--	--	--
TOTAL	15,818,000	1,782,700	533,060		13,332,600	16,515,800	14,114,100

*(BCY): Bank Cubic Yards; (LCY): Loose Cubic Yards; (CCY): Compacted Cubic Yards; (UNC): Uncontaminated Areas; (NA): Volume Estimate not available at 2/6/87; (CU): Considered uncontaminated or no Phase II investigations planned as of 2/6/87.
** Volume Estimates rounded to nearest 100 bcy based on current RI/FS Studies or the DALF.

TABLE A-3

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map[1/] Designation	Task Number	Comment
1-1	Drainage Ditches	Pink	7	Separate CAR Report.
1-2	Upper and Lower Derby Lakes	Pink	12	Separate CAR Report.
1-3	Mounded Material	Pink	2	Separate CAR Report.
1-4	Borrow Pit	Blue	2	Separate CAR Report.
1-5	Revetted Storage Areas	Pink	2	Separate CAR Report.
1-7	Hydrazine Blending and Storage	Pink	11	Separate CAR Report.
1-8	Salvage Yard	Pink	2	Separate CAR Report.
1-9	Open Storage Area	Blue	7	Separate CAR Report.
1-10	South Tank Storage Area	Pink	2	Separate CAR Report.
1-11	Sanitary Landfill	Blue	2	Separate CAR Report.
1-12	Trash Dump	Pink	12	Separate CAR Report.
1-13	South Plants Area	Pink	2	Separate CAR Report.
2-1	Drainage Ditches	Blue	7	Separate CAR Report.
2-2	Firebreak	Pink	2	Separate CAR Report.
2-3	Lagoon	Pink	2	Separate CAR Report.
2-4	Excavation or Ground Scar	Blue	2	Separate CAR Report.
2-5	Trench	Blue	2	Separate CAR Report.
2-6	Salt Storage Area	Pink	2	Separate CAR Report.
2-7	Aeration Basin	Pink	2	Separate CAR Report.
2-8	Former Tank Storage Area	Pink	2	Separate CAR Report.
2-9	Open Storage Area	Pink	2	Separate CAR Report.
2-12	Location for Former Tanks	Blue	2	Separate CAR Report.
2-13	Former Open Storage Area	Blue	2	Separate CAR Report.
2-14	Sanitary Landfill	Pink	2	Separate CAR Report.
2-17	Ladora Lake and Mary Lake	Pink	7	Separate CAR Report.
2-18	South Plants Area	Pink	2	Separate CAR Report.
3-2	Drainage Ditch and Overflow Basin (includes 3-3)	Pink	7	Separate CAR Report.

1/ Campbell and Witt. September, 1983. Selection of a Contamination Control Strategy for Rocky Mountain Arsenal. 2 vols. USATHAMA Final Report, RIC No. 83326R01. 1 in = 1,000 ft Color Map, titled Areas Investigated as Potential Contamination Sites on RMA.

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TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
3-4	Nemagon Spill Area	Pink	7	Separate CAR Report.
4-2	Burning Pit	Pink	15	Separate CAR Report.
4-3	Burning Pit	Pink	15	Separate CAR Report.
4-4	Burning Pits	Pink	15	Separate CAR Report.
4-5	Borrow Pit	Blue	15	Separate CAR Report.
4-6	Motor Pool Area	None	38	Separate CAR Report.
5-2	Area of Potential H and HD Contamination	Pink	15	Separate CAR Report.
6-2	Upper Derby Lake	Pink	12	Separate CAR Report.
6-5	GB Spill	Pink	15	May be considered uncontaminated.
6-6	Former Toxic Gas Storage Yard	Pink	15	Separate CAR Report.
11-1	Buried Lake Sludge	Pink	12	Separate CAR Report.
12-1	Buried Lake Sludge	Pink	12	Separate CAR Report.
12-2	Rod and Gun Club Pond	Pink	12	Separate CAR Report.
19-1	Burn Site	Pink	14	Separate CAR Report.
20-1	Burn Site	Pink	14	Separate CAR Report.
24-6	Sewage Treatment Plant and Ponds	Pink	7	Separate CAR Report.
24-7	North Bog	None	7	"New" Site; Separate CAR Report.
26-3	Basin C	Pink	6	Separate CAR Report.
26-4	Basin D	Pink	6	Separate CAR Report.
26-5	Basin E	Pink	6	Separate CAR Report.
26-6	Basin F	Pink	6	Separate CAR Report.
26-7	Surface Drainage from Basin A	Pink	6	Separate CAR Report.
29-1	Burn Site	Pink	14	Separate CAR Report.
29-4	Disposal Area	Pink	14	Separate CAR Report.
29-5	Disposal Site (includes 32.01)	Pink	14	Separate CAR Report.
30-1	Impact Area	Pink	14	Separate CAR Report.
30-2	Burn Site	Pink	14	Separate CAR Report.
30-3	H Training Area	Pink	14	Separate CAR Report.
30-4	Sanitary Landfill	Pink	7	Separate CAR Report.
30-5	Demil Operation Area	Pink	14	Separate CAR Report.
30-6	Trenches	Pink	14	Separate CAR Report.
30-7	Ground Disturbance	Pink	14	Separate CAR Report.

TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
31-2	VX and GB Soil Contamination	Pink	15	May be considered uncontaminated.
31-4	New Toxic Gas Storage Yard	Pink	15	Separate CAR Report.
31-6	Storage Sheds	Pink	15	Separate CAR Report.
31-7	Storage Shed	Pink	15	Separate CAR Report.
32-5	Burning Pits	Pink	15	Separate CAR Report.
32-6	Burning Pits	Pink	15	Separate CAR Report.
35-3	Basin B	Pink	6	Separate CAR Report.
35-4	Drainage from Basin A	Pink	6	Separate CAR Report.
35-6	Munitions Test Area	Pink	14	Separate CAR Report.
35-7	Firing Range	Pink	14	Separate CAR Report.
36-1	Basin A	Pink	1	Separate CAR Report.
36-2	Incendiary Drop and Munitions Test Area	Pink	14	Separate CAR Report.
36-3	Insecticide Pits	Pink	1	Separate CAR Report.
36-4	Lime Settling Basins	Pink	1	Separate CAR Report.
36-5	Mercury Compound Spill	Pink	1	Separate CAR Report.
36-6	Probable Test Site	Pink	14	Separate CAR Report.
36-7	Sanitary and Shell Disposal Sites	Pink	1	Separate CAR Report.
36-8	Open Chemical Drainage	Pink	1	Separate CAR Report.
36-9	Incendiary or Munitions Test Site	Pink	14	Separate CAR Report.
36-10	Large Pit	Pink	1	Separate CAR Report.
36-11	Liquid Storage Pools	Pink	1	Separate CAR Report.
36-12	Pits or Trenches	Pink	1	Separate CAR Report.
36-13	Trenches	Pink	14	Separate CAR Report.
36-14	Disposal Site	Pink	14	Separate CAR Report.
36-15	Burning Site	Pink	1	Separate CAR Report.
36-16	Incendiary Burial Site	Pink	14	Separate CAR Report.
36-17	Complex Disposal/Activity Sites	Pink	1	Separate CAR Report.
36-18	Possible Trench Disposal Sites	Pink	14	Separate CAR Report.
36-19	Ground Scars	Blue	14	Separate CAR Report.
36-20	Chemical Sewer Line	Pink	1	Separate CAR Report.
36-21		None	1	"New" Site; Separate CAR Report.
36-22		None	1	"New" Site; Separate CAR Report.

TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
36-23	Debris Pile from Basin A	None	1	"New" Site; Separate CAR Report.
1-UNC	Uncontaminated Areas	None	7	Separate CAR Report.
1-6	Open Storage Area	Blue	7	Included in uncontaminated areas.
2-UNC	Uncontaminated Areas	None	7	Separate CAR Report.
2-10	Ground Scar	Blue	7	Included in uncontaminated areas.
2-11	Open Storage	Blue	7	Included in uncontaminated areas.
2-15	Open Storage Area	Blue	7	Included in uncontaminated areas.
2-16	Pit	Blue	7	Included in uncontaminated areas.
3-UNC	Uncontaminated Area	None	15	Separate CAR Report.
4-UNC	Uncontaminated Area	None	15	Separate CAR Report.
5-UNC	Uncontaminated Area	None	15	Separate CAR Report.
5-1	Bomb Storage Sites	Blue	15	Included in uncontaminated areas.
6-UNC	Uncontaminated Area	None	15	Separate CAR Report.
6-1	Drainage Ditches	Blue	15	Included in uncontaminated areas.
6-3	Storage Area	Blue	15	Included in uncontaminated areas.
6-4	Salt from Mustard Demil	Blue	15	Included in uncontaminated areas.
6-7	HE Storage Yard	Blue	15	Included in uncontaminated areas.
6-8	Storage Sheds or Bunkers	Blue	15	Included in uncontaminated areas.
6-9	Vegetation Stress	Blue	15	Included in uncontaminated areas.
6-10	Trenches	Blue	15	Included in uncontaminated areas.
6-11	Trench	Blue	15	Included in uncontaminated areas.
6-12	Possible Excavation	Blue	15	Included in uncontaminated areas.
6-13	Excavation	Blue	15	Included in uncontaminated areas.
6-14	Open Storage	Blue	15	Included in uncontaminated areas.
6-15	Stoage Sheds	Blue	15	Included in uncontaminated areas.
7-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
7-1	Bomb Storage Sheds	Blue	15	Included in uncontaminated areas.
8-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
8-1	Bomb Storage Sheds	Blue	15	Included in uncontaminated areas.
9-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
9-1	Ground Disturbance, Radio Tower	Blue	15	Included in uncontaminated areas.
9-2	Excavation or Mound	Blue	15	Included in uncontaminated areas.

TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
11-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
11-2	Disturbed Area	Blue	15	Included in uncontaminated areas.
12-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
19-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
19-2	TX Production Site	Blue	14	Included in uncontaminated areas.
20-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
20-2	TX Production Site	Blue	14	Included in uncontaminated areas.
22-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
23-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
23-1	Suspected TX Disposal Well	Blue	14	Included in uncontaminated areas.
23-2	Suspected TX Disposal Well	Blue	14	Included in uncontaminated areas.
23-3	TX Production Site	Blue	14	Included in uncontaminated areas.
24-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
24-1	Suspected TX Burial Site	Blue	14	Included in uncontaminated areas.
24-2	Suspected TX Disposal Well	Blue	14	Included in uncontaminated areas.
24-3	Suspected TX Disposal Well	Blue	14	Included in uncontaminated areas.
24-4	TX Production Area	Blue	14	Included in uncontaminated areas.
25-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
25-1	TX Production Area	Blue	14	Included in uncontaminated areas.
26-UNC	Uncontaminated Areas	None	6	Separate CAR Report.
26-1	Deep Disposal Well	Pink	6	Included in uncontaminated areas.
26-2	TX Production Area	Blue	6	Included in uncontaminated areas.
26-10	Lined Pond	Blue	6	Included in uncontaminated areas.
27-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
27-1	Basin G	Blue	14	Included in uncontaminated areas.
27-2	Ground Scar	Blue	14	Included in uncontaminated areas.
27-3	Ground Scar	Blue	14	Included in uncontaminated areas.
28-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
29-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
29-2	Ground Disturbances	Blue	14	Included in uncontaminated areas.
29-3	Burn Site	Blue	14	Included in uncontaminated areas.
29-6	Ground Disturbance	Blue	14	Included in uncontaminated areas.
30-UNC	Uncontaminated Areas	None	14	Separate CAR Report.

TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
31-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
31-1	Storage Sheds	Blue	15	Included in uncontaminated areas.
31-3	Warehouse	Blue	15	Included in uncontaminated areas.
31-5	Disturbed Ground	Blue	15	Included in uncontaminated areas.
31-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
32-2	Ground Scars	Blue	15	Included in uncontaminated areas.
32-3	Open Storage Areas	Blue	15	Included in uncontaminated areas.
32-4	Storage Shed	Blue	15	Included in uncontaminated areas.
32-7	Storage Sheds	Blue	15	Included in uncontaminated areas.
32-8	Ground Disturbance	Blue	15	Included in uncontaminated areas.
33-UNC	Uncontaminated Areas	None	15	Separate CAR Report.
34-UNC	Uncontaminated Areas	None	14	Separate CAR Report.
34-3 (?)	Scarified Ground	Blue	14	Included in uncontaminated areas.
35-UNC	Uncontaminated Areas	None	6	Separate CAR Report.
35-5	Ground Disturbance	Blue	6	Included in uncontaminated areas.
35-8	Storage Area	Blue	6	Included in uncontaminated areas.
35-9	Caustic Holding Basin	Blue	6	Included in uncontaminated areas.
36-UNC	Uncontaminated Areas	None	1	Separate CAR Report.
South Plants Regional	Manufacturing Area	Misc.	2	Separate South Plants Area CAR Report.
Spill Sites	Arsenal-wide	Misc.	24	Separate Spill Sites CAR Report.
Buildings	Arsenal-wide	Misc.	24	Separate Buildings CAR Report.
25-4	Building 1501	Pink	24	Separate Buildings CAR Report.
25-5	Building 1503	Pink	24	Separate Buildings CAR Report.
25-6	Building 1504	Pink	24	Separate Buildings CAR Report.
25-7	Building 1506	Pink	24	Separate Buildings CAR Report.
25-8	Building 1601	Pink	24	Separate Buildings CAR Report.
25-9	Building 1603	Pink	24	Separate Buildings CAR Report.
25-10	Building 1606	Pink	24	Separate Buildings CAR Report.
25-11	Building 1614	Pink	24	Separate Buildings CAR Report.
25-12	Building 1615	Pink	24	Separate Buildings CAR Report.
25-13	Building 1616	Pink	24	Separate Buildings CAR Report.

TABLE A-3 (Continued)

INDEX OF RMA SITES

Site Number or Designation	Site Name	Tricolor Map Designation	Task Number	Comment
25-14	Building 1703	Pink	24	Separate Buildings CAR Report.
25-15	Building 1727	Pink	24	Separate Buildings CAR Report.
25-16	Manufacturing Areas	None	42	Separate North Plants Area CAR Report.
3-1	Sanitary Sewer Line	Blue	10	Separate Sewers CAR Report.
4-1	Sanitary Sewer Line	Blue	10	Separate Sewers CAR Report.
24-5	Sanitary Sewer Line	Pink	10	Separate Sewers CAR Report.
25-2	Sanitary Sewer Line	Pink	10	Separate Sewers CAR Report.
25-3	Chemical Sewer Line	Pink	10	Separate Sewers CAR Report.
26-8	Sanitary Sewer Line	Pink	10	Separate Sewers CAR Report.
26-9	Chemical Sewer Line	Pink	10	Separate Sewers CAR Report.
34-2	Sanitary Sewer Line	Blue	10	Separate Sewers CAR Report.
35-1	Sanitary Sewer Line	Pink	10	Separate Sewers CAR Report.
35-2	Chemical Sewer Line	Pink	10	Separate Sewers CAR Report.

APPENDIX II

LAND DISPOSAL CONCEPTS

II.0 LAND DISPOSAL CONCEPTS

This Appendix reviews the technology available for waste disposal facilities. Causes of failure and success at existing facilities are discussed, the state-of-the-art in facility design, construction and operation is presented, and examples of facilities having particular relevance to RMA are examined individually. The failure review and state-of-the-art discussions are drawn from EPA studies and guidance documents. The example facilities descriptions are based on review of the design and licensing documents for those facilities.

II.1 GENERAL

Land disposal practices have evolved over the years from municipal open dumps, to landfills, to the present practice of incineration or other treatment of municipal, hazardous, and nuclear wastes followed by land disposal in engineered facilities.

Old landfills, including many still in operation, were often developed with little regard for engineering considerations of the site, such as soil type and groundwater conditions. Landfills were developed in excavated pits or natural depressions with uncontrolled waste placed in them and not covered on a daily basis. Large quantities of hazardous materials were often disposed in municipal landfills. As a result, severe environmental damage resulted from rainfall percolating through the waste and leaching into the water table. Once entering the water table, the leachate migrated off-site and in many cases contaminated surrounding wells or surface water sources. Failure to minimize and control leachate production was the primary cause of environmental damage from sanitary landfills. The lack of proper design meant limited removal of leachate before it intercepted the water table. If designs did provide for leachate removal, they often provided no means to detect failure of the system until environmental damage had been done (i.e., water supply sources contaminated).

Potential and actual adverse public health effects caused by landfills gave rise to the regulation of landfills and the development of engineering concepts of land disposal facility design and operation. Siting came to include consideration of potential impact to groundwater, reliable containment, and methods of operation that would reduce potential adverse effects. Engineered landfills involved a more technical approach, including assessments of water table elevations, soil sampling and testing, and design of new features of the waste pit such as clay or flexible membrane liners.

As regulated disposal of hazardous waste in land disposal sites has expanded, new sites have incorporated various improvements. The improvements over prior facilities included such things as multiple liner systems, leachate collection and treatment systems, gas collection systems, and improved covering techniques. A review of land disposal facility failures and the state-of-the-art design responses to these failures follows.

The waste cell concepts for the Rocky Mountain Arsenal will reflect the state-of-the-art techniques in containment of hazardous wastes for the protection of the environment.

II.2 REVIEW OF FAILURE STUDIES

II.2.1 General

The Environmental Protection Agency has conducted studies of land disposal facilities based on survey information supplied by vendors and facility operators (Arthur D. Little, Inc., 1985b; EPA, 1985a). Because of the relatively recent introduction of synthetic membrane liners and complex engineered disposal facilities, there are few long-term case studies of such projects available. The long-term case studies generally consist of older, unlined projects, which have experienced problems such as groundwater contamination as time progressed. This section provides information on the various modes of failure that have occurred at land disposal facilities and concludes with factors that have contributed to successes.

II.2.2 Failure Mechanisms

II.2.2.1 <u>Design</u>

One of the basic factors leading to failure of a land disposal facility has been poor or inadequate design:

- The subgrade material or material between liners was too coarse and failure occurred as a result of puncture;

- Leachate collection system was undersized;

- Improper liner selection based on liner compatibility with the waste;

- Lack of adequate run-on and runoff control; and

- Lack of adequate gas collection systems.

II.2.2.2 Quality Control

EPA studies suggest that lack of quality control in installation is one of the major causes of failures in liner systems and in land disposal facilities. This lack of quality control includes:

- Poor bonding at seams between liner panels;

- Liners placed over or between coarse rock;

- Thin soil cover over liners resulting in punctures by heavy equipment; and

- Work not meeting design specifications generally.

II.2.2.3 Physical Failure

There are a number of modes of liner failure due to physical processes and stresses:

- Puncture or tear failure can occur in liners under certain circumstances. It can occur due to improper placement of synthetic liners directly over or between coarse materials, long term migration of fine materials exposing the liner to sharp rocks in the subgrade, operations by equipment such as bulldozers, and occasionally intrusion by hoofed animals when cover soils are too thin.

- o Failure resulting from creep is caused by a sustained load with increasing deformation of the liner material.
- o Liners exposed to freeze-thaw cycles can undergo cracking as a result of liquid volume expansion in pore spaces during freeze cycles.
- o Wet-dry cycle cracking is associated with clay liners exposed to weathering.
- o Differential settling typically occurs when foundations are improperly prepared.
- o Thermal stress results from temperature gradients that cause volume changes in the liner material when they are exposed to weathering.
- o Hydrostatic pressure from uncontrolled liquid levels inside or outside a cell or a liner can result in failure.
- o Abrasion can cause significant wear to an exposed liner over time, which can lead to failure.

II.2.2.4 Biological Failure

Biological modes of failure may consist of microbial or small animal attack. Small animals may attack synthetic membrane liners and eat them. Clay liners may be penetrated by burrowing animals.

II.2.2.5 Chemical Failure

Failures of liners because of chemical reactions occur because hazardous wastes contained in disposal facilities may be composed of organic and inorganic chemicals with the potential to react with synthetic and clay liner materials (EPA 1983).

II.2.3 Factors Contributing to Success

The two main elements of success are considered to be: 1) a proper engineering approach, and 2) the extensive use of quality assurance programs throughout all phases of facility construction and operation (Arthur D. Little, Inc., 1985b). Those responsible for the facility must therefore understand the importance and complexity of the undertaking. A successful approach is to assume there will be problems and take appropriate steps to avoid or minimize the consequences.

Other factors that have been found to contribute to successful construction and operation of land disposal facilities include: 1) overdesign of the system; 2) building to specifications; 3) selection of qualified engineers and contractors; 4) cooperation among companies performing the work; 5) conducting waste-liner compatibility tests; 6) simplicity of design; and 8) good weather (Arthur D. Little, Inc., 1985b).

II.3 STATE-OF-THE-ART

II.3.1 General

The state-of-the-art in land disposal facilities has evolved over time through assessment of past practices and results, the introduction of new materials and concepts, and efforts generally directed at solving specific problems that have occurred at various sites. Past practices resulting in problems have encouraged the study and solution of the individual modes of failure. The following sections discuss state-of-the-art techniques, materials, and concepts.

II.3.2 Quality Control

The quality control aspects of liner installation and landfill construction are critical to the success of any land disposal facility. The degree of waste containment is only as good as the technology installed. The critical nature of installation quality dictates that a qualified team of quality control personnel monitor all aspects of construction. This requires a comprehensive inspection and audit program to ensure attainment of design specifications. Proper installation of synthetic and clay liners, as well as all other systems within a hazardous waste land disposal facility, requires strict adherence to detailed installation procedures to achieve facility performance specifications.

II.3.3 Foundation

The foundation for any type of liner system, from synthetic to soil or clay, requires a firm and unyielding base. A properly constructed foundation reduces the possibility of failures due to puncture, tear, creep, and differential settling.

Foundation design requires appropriate site exploration and testing including evaluation of the regional geology, foundation soil boring and sampling, and other site and laboratory investigations where necessary to evaluate subsurface conditions. The proper use of this information in foundation design will ensure that a waste cell foundation will not subside under the loads imposed during placement operations or over time once a cell is completed.

Subgrades and fill embankment slopes forming the base and sides of any waste cell require treatment similar to any engineered embankment structure. Subgrades composed of fill are constructed in a series of individually compacted layers or lifts to ensure uniform compaction. Thickness of lifts is evaluated based on the type of material being used, the compaction equipment, the required amount of compaction, moisture content, and final density required. Inspection and testing of engineered fills during construction of each of these attributes provides insurance against subsidence.

Excavated subgrades are generally compacted only at the surface. The regularity and texture of the surface layer in the compaction scheme is critical to liner installation, particularly synthetic liners. Rocks or other irregularities, particularly with sharp edges, should be eliminated prior to installation of a flexible membrane liner.

II.3.4 Liners

II.3.4.1 Waste Compatibility and Liner Materials

Numerous liner materials, both natural and synthetic, have been used for containment of wastes, with the selection based on several factors.

The most consistently important factor in liner selection is compatibility of liner and waste, since incompatibility implies the possibility of chemical reactions that can destroy the integrity of the natural or synthetic liner. Research has been conducted to test the reactivity of common hazardous waste materials with common liner materials, both natural and synthetic (Arthur D. Little, Inc., 1985a; EPA, 1978, 1983). Natural materials tested have included soils and clays. Synthetics tested have included chlorinated polyethylene, high density polyethylene, chlorosulfonated polyethylene, and polyvinyl chloride. Testing has been conducted through the use of numerous methods such as direct application of waste to natural and synthetic materials and the pouch test for synthetics to determine permeability.

Based on this research, liner selections can be made on a preliminary basis with respect to the waste to be contained. When highly concentrated wastes are to be contained, or if wastes are not well documented or previously studied, compatibility testing is required during design or predesign phases for appropriate liner selection.

Related subjects are waste-to-waste compatibility and the segregation of incompatible wastes. These arise when there are a number of different wastes are involved, such as at RMA. The wastes have the potential for generating reaction by-products incompatible with a specific liner, even though the original wastes may be compatible with the liner material, in addition to generation of heat and liberation of gases and liquids. Incompatible wastes, depending on concentration and volume, may, therefore, need to be segregated into separate waste cells or neutralized prior to placement.

II.3.4.2 Multiple Layers

Current hazardous waste land disposal practice requires the use of multiple liner systems in combination with leachate collection systems (IT Corporation, 1984). Multiple liners provide a backup or redundant system in the event the first barrier is breached.

Multiple liner systems can consist of combinations of natural and synthetic liner layers or multiple synthetic liners. The most common system found in the literature review was a clay foundation liner overlain by one or more synthetic membrane liners.

The number of liners used in any given design is dependent on the relative hazard of the waste, the required containment design period, and applicable agency regulations.

II.3.4.3 Foundation Layer

The foundation layer of the waste cell bottom liner system is often made of clay. Clay foundation layers have ranged from approximately 2 to 25 feet in thickness. The thicker foundations are typically compacted clay on an existing clay surface. In multiple liner systems, the clay liner acts as a final barrier to contaminant migration in the event of a failure of the upper liner.

One of the desirable characteristics of clay as a final barrier is its ion exchange capability. Testing has shown that concentrations of hazardous materials in leachates percolating through clay materials will generally be reduced as a result of ion exchange. This is particularly true in the case of heavy metals. The cation exchange capacity varies from high to low in the order of montmorillonite, illite, and kaolinite. The exchange capacity has also been shown to be highly dependent on the pH of the leachate (EPA, 1978). Organic materials also react with components within the clay matrix and can reduce the hazardous component of the leachate. Heavy metal or organic ions become a part of the clay matrix replacing less hazardous or nonhazardous ions, which are released. A drawback is that excessive leachate can saturate the clay matrix over time with replacement ions and chemically break down the matrix, resulting in increased permeability and loss of further exchange capability.

Synthetic liners are also used as the foundation layer in multiple liner systems. Surface preparation requirements are more stringent for a synthetic foundation membrane compared to a compacted clay foundation. As described previously, the synthetic liner is prone to tear and puncture and, therefore, requires a greater degree of surface preparation to remove rocks and other irregularities in the subgrade surface.

Any synthetic membrane liner upon which construction equipment will operate requires a cover layer of 1 or 2 feet of material to protect it from puncture or tears during construction and operation of the waste cell.

II.3.4.4 Cover Layer

A well engineered and constructed waste cell cover provides the initial barrier to contaminant and leachate migration by reducing water infiltration and subsequent leachate production and percolation through contaminated materials.

As with the bottom liner system, covers are generally multiple-liner systems using natural and synthetic materials in various combinations. Current standards stress the importance of the cover system by requiring permeability rates less than or equal to the bottom liner system. Cover systems typically include a buffer or gas collection layer directly above the waste material, a filter layer of either sandy material or filter fabric, one or more barrier layers consisting of clays or synthetic membranes, a drainage layer, a loam or topsoil layer, and a vegetated or armored cover layer (EPA, 1982).

Specific factors or considerations relating to the cover system include materials selection, water storage capacity of soils, evapotranspiration rates, freeze-thaw cycles, rainfall, vegetative cover, surface and subgrade drainage, surface slopes, and wind and water erosion potential.

Rainfall intensity during normal precipitation or storm periods influences the surface slope selected to promote groundwater runoff while avoiding erosion of the surface soils. Slopes as low as 5 percent have been suggested; however, the general practice is a maximum slope of 4:1 (EPA, 1982). Some reduction in runoff unavoidably occurs through infiltration into the cover soil, the amount depending on the nature of the surface and the soil's capacity to hold or transmit water. Evapotranspiration releases soil moisture in to the atmosphere and reduces net infiltration. Infiltrated water penetrating to the bottom of the soil layer encounters a drainage layer above the uppermost barrier.

The depth of the loam or soil cover layer required is that which will prevent freezing and thawing of the more sensitive components of the cover system. The sensitive components include the clay or synthetic membrane barrier layers.

Wind erosion is reduced by appropriate side slope selection, orientation of the waste cell, and the final cover. The final cover may be armor rock or vegetation, depending on circumstances such as climate and desired maintenance effort.

II.3.5 Leachate Collection and Treatment

Waste cells are provided with leachate detection, collection, and treatment systems. These systems provide detection of primary liner failure, prevent a buildup of hydraulic head on liners from liquid infiltration, and remove excess liquids from the cells in a controlled manner.

The leachate collection systems control leachate migration, the major mechanism of contaminant migration outside the cell. Collection systems are designed to provide gravity drainage and adequate discharge capacity at low hydrostatic heads.

The systems generally include a layer of porous material to collect the liquids and a series of lateral pipes that transport the liquid within the cell to a main discharge pipe from which it flows outside the waste cell to a storage or treatment unit. Geotextiles are sometimes incorporated into the design to prevent migration of the porous material into the pipe system.

Design considerations to prevent failure of leachate collection systems include pipe location, redundancy, and maintenance features. Pipe location and placement are critical to avoid crushing or displacement by equipment loading and differential settling (EPA, 1985). A pipe is best protected when it is placed in a trench, with careful consideration given to loading conditions and proper bedding to provide protection for the pipe, especially during placement of the first lift of waste when the pipe is most susceptible to crushing.

Redundancy in design is important to minimize the effect of individual failures. The system should be able to remove liquid from any point in the facility by more than one pathway (EPA, 1985). One of the primary ways to provide redundancy is to design collection laterals to allow drainage by the porous layer alone if flow through a lateral is restricted. In addition, laterals should be spaced so liquid can be removed through an adjacent lateral if one lateral is completely blocked.

Leachate collection systems can be designed to avoid specific clogging mechanisms. For example, sedimentation can be avoided by selecting the proper grain size distribution for the filter material, incorporating geotextiles into the design, and providing minimum slope to maintain flow velocity so that solids cannot settle out. Maintaining flow velocity will prevent buildup of biological and chemical materials. Proper selection of construction materials based on the wastes to be handled avoids deterioration caused by reactions with waste leachates.

Leachate collection system construction according to design specifications is critical. Construction quality assurance (CQA) is necessary to verify that the completed leachate collection system meets or exceeds the design requirements. This involves monitoring and documenting the quality of materials used and the conditions and manner of their placement (EPA, 1985).

Another important consideration to prevent failure is designing the system to facilitate inspection and maintenance. Cleaning and inspection access should be provided to all parts of the system. This includes the placement of manholes and cleanouts so that maintenance equipment can reach any section of pipe. The design should consider minimum pipe size, distance between access points, and maximum angles negotiable by maintenance equipment. Regular inspections include monitoring flow at outlets or access points, monitoring leachate level within the facility, correlating leachate quantity with rainfall data, and correlating leachate quality with clogging indicators, such as the presence of iron-reducing bacteria. These periodic inspections will allow the detection of any problems that require corrective measures.

The final requirement of state-of-the-art leachate collection systems is an ongoing maintenance program. Although maintenance and repair often involve the same methods, regular maintenance may be the more cost-effective option.

II.3.6 Gas Collection

Gas collection systems are installed to vent the landfill to prevent pressure buildup, fire, explosion, or off-site migration of gases produced in the wastes. Chemically hazardous gases are discharged within applicable air quality standards or treated prior to discharge to meet the standards.

The collection and venting systems are composed of a layer of coarse graded sands or gravel placed directly on the surface of the waste material as the initial layer of the cover system and associated vent piping or of vent piping alone, located at local high points. Gases generated are collected and discharged to the atmosphere or to a treatment facility through vents at regular intervals.

II.3.7 Run-on and Runoff Control

Run-on control is provided by maintaining ground contours that slope away from the cells to prevent water from traveling toward the cells. Run-on control prevents runoff from surrounding areas entering an active waste cell or passing over a closed cell. Leachate caused by rainfall within an active waste cell boundary is collected in a sump or through the leachate collection system. The collected runoff or leachate is then treated or transported off-site for treatment.

Runoff control is provided by cell grading and drainage to dissipate rainfall runoff on the cell cover so that flow concentration and consequent erosion of soil covers and abrasion of liner materials are avoided. Ground cover, such as grass, reduces the overall amount of potential runoff. Runoff from the surface of completed cells will be collected by the surface water control system, which may consist of drains, gutters, collection and transmission piping, and ditches.

II.3.8 Monitoring System

In addition to secondary leachate detection systems within the waste cells, monitoring wells are typically placed around the waste cells. The wells provide samples for determination of baseline groundwater conditions prior to waste placement, for comparison to later conditions, and upgradient conditions, for comparison with downgradient conditions, after waste placement. The monitoring wells provide a final detection system for contaminant migration from the waste cells as well as migration of contaminants toward the waste cells from other sources.

II.4 REVIEW OF PREVIOUS CONCEPT DESIGN

A concept design was prepared for a hazardous waste land disposal facility located on RMA to contain wastes from the Basin F closure (IT Corporation, 1984). The conceptual design of the waste cells proposed in the report was state-of-the-art based on RCRA requirements and guidelines. The stated objectives of the concept were to eliminate leachate and provide the maximum possible protection to the environment.

The facility concept design involved earthen waste cells with multiple liners for both the foundation and cover layers, a leachate control system, a surface water run-on and runoff control system, monitoring wells, a gas collection and venting system, and support facilities. Six cells were designed, each with a waste capacity of 100,000 cubic yards, for disposing of 600,000 cubic yards of solidified Basin F wastes. Each cell would be constructed within a covered building for weather protection of the working area.

During the concept design study, three waste cell types were evaluated, including an earthen cell, a reinforced concrete cell, and a slurry trench cell. An earthen waste cell was selected because it could utilize the lowest permeability liners, would be flexible with regard to location, and could be constructed with common earthmoving equipment and procedures. Three liner types were evaluated for use in the top and bottom liner systems: clay, synthetic membrane, and soil cement. Consideration was given to permeability, leachate compatibility, long- and short-term integrity, constructibility, and economics. The clay and synthetic liners were considered suitable for the waste cell concept. The soil-cement liner was judged unsuitable because of a higher permeability, greater cost, and unproven technology for use in hazardous waste disposal facilities.

The selected bottom liner system included three liners: a double layer of 100 mil HDPE (high density polyethylene) synthetic liner and a single 2 foot thick compacted clay liner. The synthetic liner was considered the more suitable for the upper layers of the bottom liner system because it is more resistant to concentrated leachate. The clay liner was considered more suitable for the lower layer of the liner system because clays are known to have a better long-term life than synthetics, are naturally self-sealing, and will maintain a low permeability indefinitely unless the chemical composition is severely altered through chemical interactions. The compatibility of the clay minerals in a clay liner with any potential leachate from the waste would be evaluated during final design. Synthetics were stated to have a greater potential to deteriorate with time, based on current evidence, and field seams were considered to be long-term weak points. The useful life of synthetics was determined to be not well known because of their relatively recent introduction and corresponding lack of long-term case histories.

The conceptual design located the leachate collection and detection layers above and between the two synthetic liners. Above the uppermost synthetic liner in the foundation liner system, a series of collection pipes were located to drain any leachate to a collection sump. The base of the cell was sloped at a 4 percent grade to drain the leachate to the sump by gravity. Between the two synthetic liners a granular or porous fill and associated piping a leachate detection layer. The leachate control system also included a compacted clay bulkhead along the perimeter for additional protection against leakage and an at-grade steel collection tank underlain by an HDPE liner. Any leachate generated would be drained by gravity from the waste cells to the tank.

The cover system consisted of a triple-lined system with a permeability equal to or lower than the foundation liner/leachate collection system. The cover system included two 100 mil HDPE synthetic liners and a single 2 foot thick compacted clay liner. In addition, the cover system contained a vented gas collection layer, drainage layer, and a soil cap.

II.5 REVIEW OF RADIOACTIVE WASTE FACILITIES DESIGNS

Current designs for hazardous waste land disposal facilities have evolved in parallel with development of the disposal technologies used for solid waste and radioactive waste. Low-level radioactive waste disposal technology in the U.S. began with shallow land burial in trenches at 12 sites. Five of these trenches have failed, leading to the development of significant public resistance to the practice. Subsequent developments included the exploration of effective capping techniques and the study of substantial containment structures such as concrete vaults. Most actual experience with vault structures is at facilities in Canada and France. The most advanced commercially available technology employed in the U.S. at present is concrete canister disposal.

The French facility at La Manche uses two superimposed systems. High activity waste is embedded in concrete monoliths in a shallow trench (below ground), while low activity waste is placed on top of the monoliths (above ground) in earthen mounds. This facility uses a significant amount of concrete and has a dedicated cement plant on site.

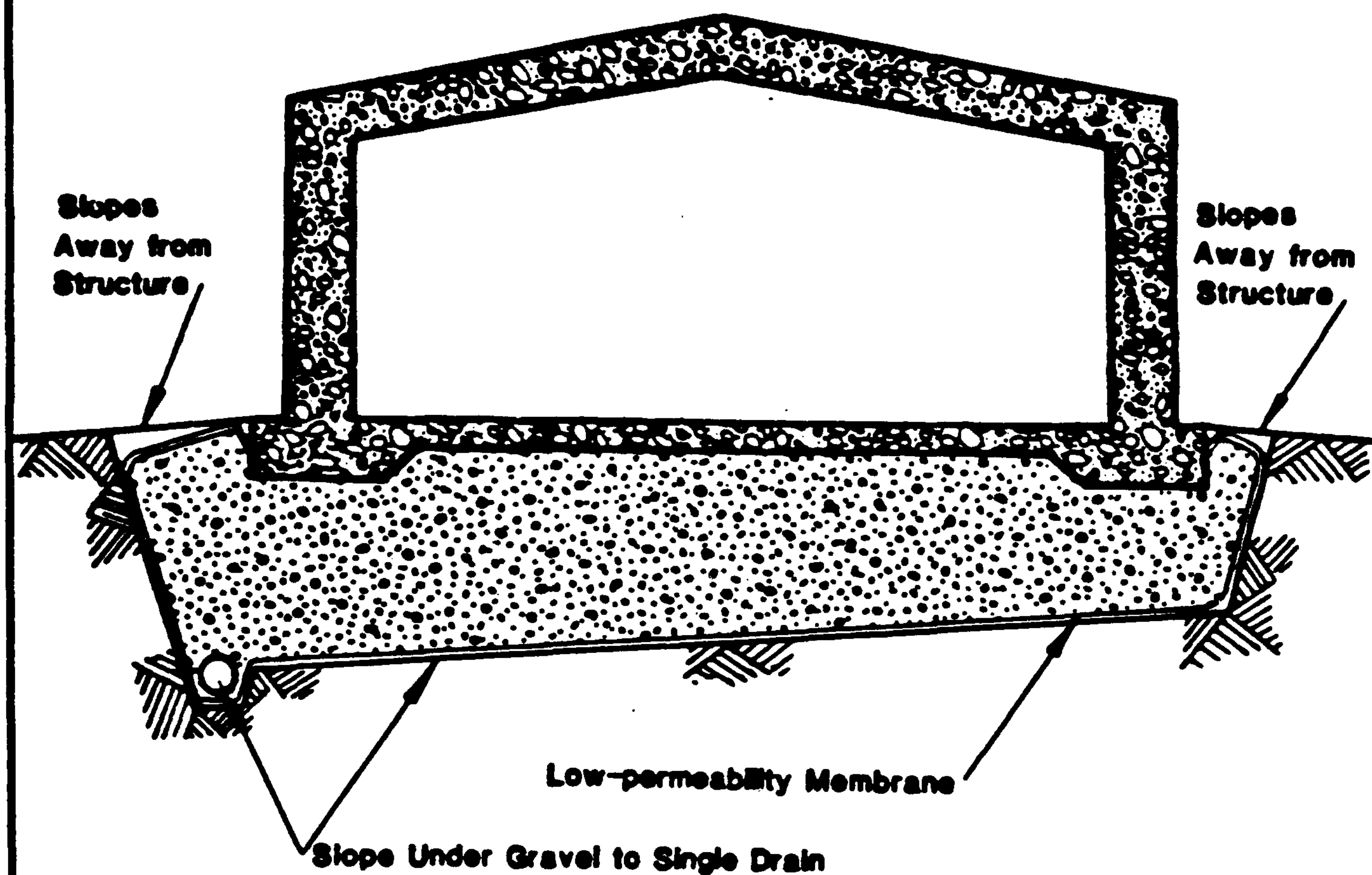
The USAEWES prepared a series of reports for the U.S. Nuclear Regulatory Commission (USAEWES, 1985). The report outlined requirements for above-ground and below-ground vault disposal of low-level radioactive wastes. Figures II-1 and II-2 show sketches of these two designs. The above-ground vault was considered to be an unattractive design for the following reasons: 1) since containment concrete is exposed, it is subjected to weathering; and 2) the design limits post-closure land use. For these reasons the below-ground vault was felt to be a superior design.

A below-ground vault similar in design to Figure II-2 is currently under construction at the DOE Hanford site. The vault is 125 ft long by 50 ft wide by 34 ft high. The vault walls are designed similar to a retaining wall and vary in thickness from 1 ft at ground level to 3-1/3 ft at the vault floor. The vault is equipped with both leachate detection and collection layers.

State-of-the-art hazardous waste land disposal facilities face similar requirements as state-of-the-art radioactive waste designs except that they must be larger in capacity. Typically, the quantity of radioactive waste placed in vaults is limited by the amount of radioactive material that can be safely placed together and by demands for a high level of radiation protection at the surface of the site. Hazardous waste, on the other hand, does not have the same quantity constraints. Designs for hazardous waste land disposal facilities may incorporate the containment features proposed for nuclear wastes with the economy of scale found in municipal solid waste facilities.

II.6 EXISTING LAND DISPOSAL FACILITIES DESCRIPTIONS

The design and permit documents for two recent state-of-the-art hazardous waste facilities have been reviewed with particular attention to how their designs relate to RMA conditions and requirements.



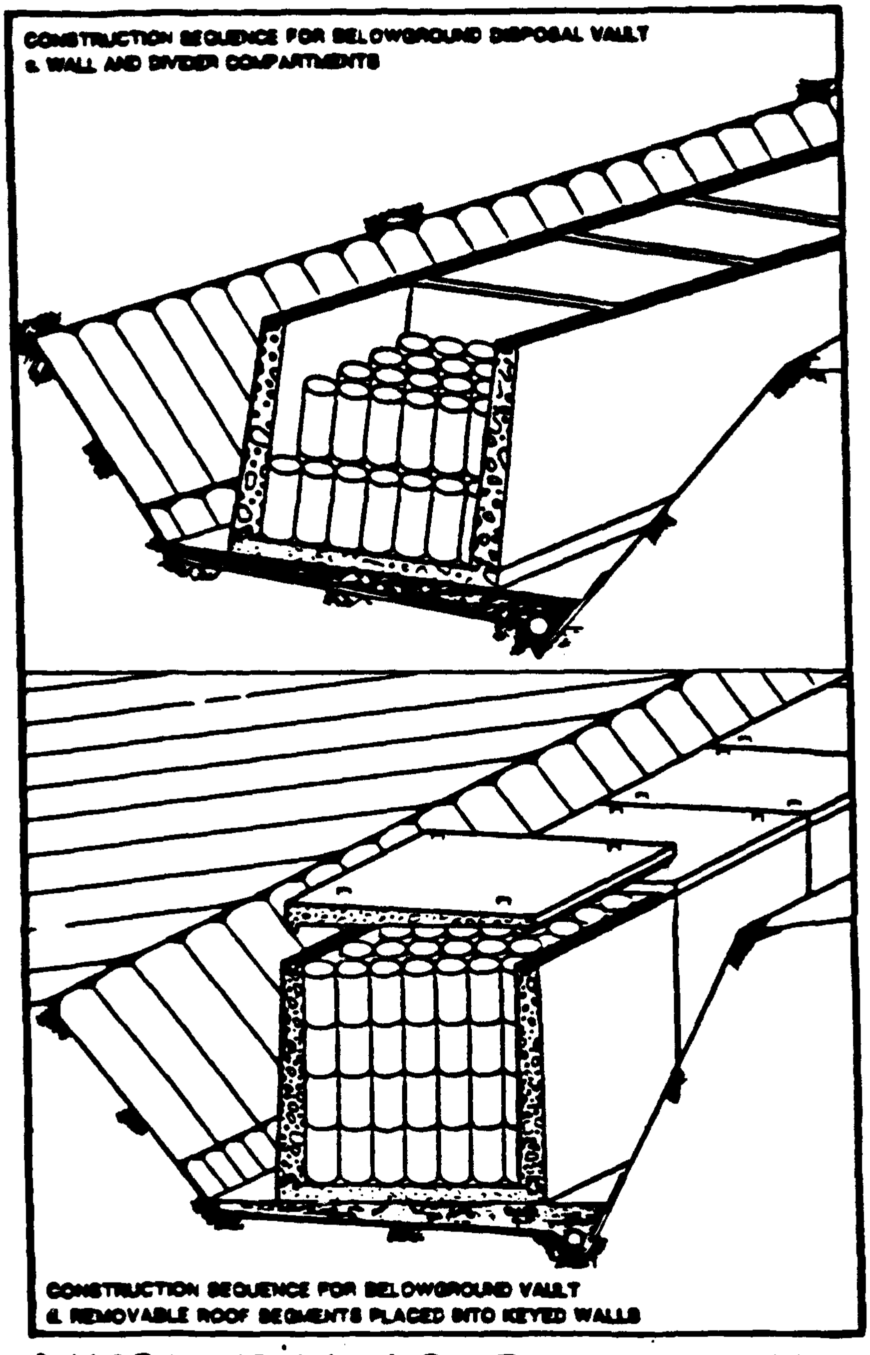
ABOVE GROUND LLW DISPOSAL VAULT

SOURCE: ALTERNATIVE METHODS FOR DISPOSAL OF LOW LEVEL RADIOACTIVE WASTES (NUREG/CR-3774 VOL. 2)

EBASCO

RMA TASK 27

FIGURE II-1



BELOWGROUND LLW DISPOSAL VAULT

SOURCE: ALTERNATIVE METHODS FOR DISPOSAL OF LOW LEVEL RADIOACTIVE WASTES (NUREG/CR-3774 VOL. 2)

EBASCO
RMA TASK 27 FIGURE II-2

II.6.1 Last Chance

On February 27, 1987, the Colorado Department of Health issued a hazardous waste permit to the Highway 36 Land Development Company, a unit of Browning-Ferris Industries (BFI), for a facility located near the town of Last Chance, Adams County, Colorado. The EPA RCRA permit was issued on March 2, 1987, following issue of the state permit. This facility was designed to store permitted hazardous waste in 16 secure landfill cells, each with a capacity of 158,000 cubic yards (total capacity of 2.5 million cubic yards). The facility was of great interest because it embodied the latest design and operating requirements and was located in Colorado at a location near RMA.

Wastes that cannot be disposed at Last Chance under the permits include the list of dioxins and organic solvents banned or limited in concentration by EPA under the revised regulations (40 CFR 268, effective November 8, 1986). Metals concentrations in waste are limited under the state permit. A comparison of the permit restrictions with the constituents of RMA wastes is provided in Table II-1.

The Last Chance site enjoys the same climatic advantages of the semi-arid high plains as RMA. It has an apparent geological advantage over RMA in that it lies over a thick bed of Pierre shale, a bedrock formation strongly promoted for hazardous waste facility siting by the Colorado Geological Survey, and an apparent hydrological advantage in that the regional groundwater table lies more than 100 feet below ground surface. However, both of these apparent advantages have been determined to be flawed upon detailed site study by the U.S. Geological Survey (Banta, 1986). The upper part of the Pierre shale is weathered and there are sandy zones, which could allow much greater hydraulic conductivity for leachate escaping the facility than unweathered Pierre shale; and there are perched water tables in the sandy zones that supply shallow wells in the area. These site defects have been mitigated by requirements imposed in the state permit for engineered barriers and monitoring, specifically the excavation of any sandy zones uncovered in the construction

TABLE II-1

LAST CHANCE PERMIT CONDITIONS
VERSUS CONSTITUENTS IN RMA WASTES

Constituent Present at RMA	Permit	Concentration Limit	Basin F Soils	Buried Sludge
Possible Exclusion				
Ethyl Benzene	Federal	0.05	1-8 (2 hits in 40)	--
Toluene	Federal	0.33	1-1,000 (7 hits in 40)	--
Xylene	Federal	0.15	10 (1 hit in 40)	--
Acceptable				
Carson Tetrachloride	Federal	0.98	ok	ok
Chlorobenzene	Federal	0.05	ok	ok
Methylene Chloride	Federal	0.96	ok	ok
Methyl Isobutylketone	Federal	0.33	ok	ok
Tetrachloroethylene	Federal	0.05	ok	ok
Arsenic	State	500	9.6	3
Cadmium	State	100	2	1.1
Chromium	State	500	19	5.7
Lead	State	500	24	26
Mercury	State	20	0.08	0.7

to a distance of 100 feet and replacement with low conductivity soil, and the installation of a large number of observation wells in sandy zones.

The design of the waste cells is a below grade, multiple-lined pit configuration. Bottom liners are one 80-mil HDPE flexible membrane and a 3 foot of clay. The cap is the same except the clay thickness is 4.5 feet (according to the state permit). The state permit requires the cover to include a drainage layer. Rodent protection consists of trapping and damage repair. Leachate removal is by pumping from sumps at the low point of each cell.

II.6.2 Grassy Mountain

The Grassy Mountain facility of U.S. Pollution Control, Inc., is located near Knolls, Utah, about 75 miles west of Salt Lake City between the shore of the Great Salt Lake and the Bonneville Salt Flats. The climate is arid to semi-arid, with about 5 inches of rain annually on average. Topographically the site is flat.

The facility is being expanded through addition of a new waste cell No. 3. The new cell is constructed on grade abutting two existing cells through construction of an earthen berm with 3:1 side slopes to a height of about 20 feet. Subsoils consist of various interlayered mixtures of clay, silt, and sand, with groundwater found at 8 to 19 feet below existing grade. Cell plan dimensions, inside crest to inside crest of the berms, are 710 by 752 feet. The bottom surface slopes 2.5 percent from the center toward leachate sumps at the perimeter; the final cover slopes 5 percent towards perimeter ditches.

The bottom liner system, which runs up the inside faces of the berms to their tops, is 7 feet thick and consists of 3 feet of clay at the bottom, overlain by a leak detection system; a primary 60 mil HDPE flexible membrane liner (FML) with a leachate removal drainage net and geotextile above it; 2 feet of soil cover; a tertiary 80 mil HDPE FML, again with leachate removal drainage net and geotextile above it; and 2 more feet of soil cover. The waste is placed on top. The leachate removal and leachate detection systems are monitored and evacuated by pumping through inclined pipes that penetrate the liner system. The cap and final cover system consist of 2 feet of clay, 80 mil HDPE FML overlain by cover drainage consisting of geonet and geotextile, two feet of final cover soil, and 4 inches of "armor plate" gravel on the surface.

The permeability of remolded native clay found at the site varies from 2×10^{-8} cm/sec at moisture content 6 percent above optimum to 1×10^{-6} cm/sec for moisture content 2 percent below optimum. In the construction of the older cells and new cell No. 3, the native clay was modified by addition of 3 pounds of sodium hexametaphosphate per 50 cubic feet of clay as a deflocculating agent to achieve in-place liner permeabilities of less than 1×10^{-7} cm/sec.

II.6.3 Descriptions of Licensed Facilities

Table II-2 provides descriptive data regarding a number of licensed hazardous waste land disposal facilities in the U.S. The data include the location, the operator, the cell dimensions and construction materials, and site data where available. It can be seen that there is a wide range of sizes, shapes, and materials used in the waste cells.

TABLE II-2

HAZARDOUS WASTE LAND DISPOSAL FACILITIES IN THE U.S.

Predominant Site Location Owner/Operator	Status	Cell Configuration: Plan Dimensions	Height	Depth	Composition of Top/ Bottom Liners	Leachate Collection/ Detection	Method of Construction	Location of Water Table	Foundation Soil
Casmalia, CA Casmalia Disposal Company	Operating	20 acres; oval	0'-0" Above Grade	50'-0" Below Grade	60 mil HDPE 3'-6" clay, sand, and gravel	Primary and secondary liner with leachate collection and detection	Working Face method with multiple layers	Nearest aquifer is 300' from site	Unweathered Claystone
Emmelle, Alaska Chemical Waste Management	Operating	900' x 900'	0'-0" Above Grade	100'-0" Below Grade	Approx. 9'-12' thick double liner with 2-60 mil HDPE	Primary and secondary liner with leachate collection and detection	Working Face method and and modular 4 modules per cell	600'-900' Below Grade	Natural Chalk Deposit
Lake Charles, LA Chemical Waste Management	Operating	---	31'-6" Above Grade	40'-0" Below Grade	Approx. 9'-6" thick double liner	Primary and secondary liner with leachate collection and detection	Working Face method and modular	At Grade	
Grand View, Idaho Envirosafe Services of Idaho	Operating	1,000'-2,000' long; 250' wide	0'-0" Above Grade	40'-50' Below Grade	HDPE Netting 12" coarse sand between layers	Primary and secondary liner with leachate collection and detection	Tier method with 3 lifts/ tier; 3" soil between lifts 1' fill between tiers	3,081' Below Grade	Brown and blue clay with some shale
Bruno, Idaho Envirosafe Services of Idaho	Operating	500' x 500'	0'-0" Above Grade	60'-70' Below Grade	---	---	---	---	Rock
Beatty, Nevada US Ecology	Operating	500' x 500'	0'-0" Above Grade	50'-0" Below Grade	Approx. 6' thick top liner; 150' thick natural clay bottom liner	None	---	300' Below Grade	Clay

Other Information

- 3 percent slopes or final cover.
- Evaporation ponds for runoff.

- Mounded at the top for drainage.

- Cell No. 5 is topped off.
- Cell No. 14 is under construction and has 3 modules.
- Cell No. 6 will be constructed later and will consist of 4-6 modules.
- 11.5' levee surrounds the site.

- Liner is a mix of bentonite and clay with a permeability of 2x10-9.
- Site elevation is 2,900'.
- 3:1 inside slope.

- Site is primarily rock which makes it too expensive to continue operating.
- Mounded for drainage.

- Mounded for drainage.
- Site is located on 80 acres of land.
- New cell under construction to be larger and above grade.

TABLE II-2 (Continued)

HAZARDOUS WASTE LAND DISPOSAL FACILITIES IN THE U.S.

Site Location Owner/Operator	Status	Cell Configuration Plan Dimensions	Height	Depth	Composition of Top/ Bottom Liners	Leachate Collection/ Detection	Method of Construction	Location of Water Table	Predominant Foundation Soil
Robstown, Texas US Ecology	Operating	200' x 300'	0'-0" Above Grade	25'-30' Below Grade	Double synthetic liners top and bottom 3" clay, 18" soil	Primary and secondary liner with leachate collection and detection	---	---	---
Grassy Mountain, Utah U.S. Pollution Control, Inc.	Operating	710' x 752'	40'-0" Above Grade	0'-0" Below Grade	7' thick liners 2-60 mil and 1-80 mil HDPE, 3' clay, 2 soil layers	Primary and secondary liner with leachate collection and detection	---	10' Below Grade	Clay and silty sand
Louisiana BF/CECOS International	Operating	650' x 375'	25'-0" Above Grade	50'-0" Below Grade	---	---	---	---	---
Kettleman City, California Chemical Waste Management	Operating	36 acres square shape internal B	90'	60'	2 synthetic, 2 clay 60 mil HDPE 3' clay	Standard multiple collection/ detection system	Layered with internal cells	500' deep	Sandstone, claystone
Benecia Disposal Facility, CA IT Environmental Corporation	Undergoing Closure	Constructing state-of-art cells in vicinity of cells undergoing closure.							
Hawkins Point Disposal Site No. 2, Annapolis, Maryland Maryland Environmental Service	Construction	---	40'	---	80 mil HDPE, 2.0' clay, 60 mil HDPE on bottom	Multiple	---	10 - 20'	Permeable
Zion, Illinois Browning Ferris Industries of Illinois	Operating	5 acres	20'	60'	Bottom-10' clay and 2 synthetics. Composit cap.	Multiple	---	10-15' Below Grade	---

Other Information

- Mounded for drainage.
- Site is located on 240 acres of land.

- 3:1 inside slope.
- All external slopes have gravel armor protection.

- Maximum waste thickness is 65 feet.
- Designing a cell which is 1,700' x 400'.

- No significant potential groundwater problems. Cap-1.5' earth, 1.5' clay (10^{-7}), 60 HDPE, drainage layer, earth, vegetation.

- Not commercial, will be used in cleanup of chrome ore tailings.

- 10' clay is Illinois State requirement.

TABLE II-2 (Continued)

HAZARDOUS WASTE LAND DISPOSAL FACILITIES IN THE U.S.

Site Location Owner/Operator	Status	Cell Configuration			Composition of Top/ Bottom Liners	Leachate Collection/ Detection	Method of Construction	Location of Water Table	Predominant Foundation Soil
		Plan Dimensions	Height	Depth					
Arizona (Phoenix area) ENSCO, Inc.	Permitting/ Construction	---	---	300'	Double synthetic with recompacted clay foundation (10^{-5}-10^{-7})	Multiple	Horizontal due to depth	400' below grade	---
Texas City, Texas Gulf Coast Waste Disposal Authority	Operating	250' x 800'	20'	15'	3' clay, 60 mil HDPE, 2' clay, 60 mil HDPE	Multiple, gravity	Continuous trench	Below clay layer (260')	260' Beaumont clay
Arlington, Oregon Chem-Securities Systems Inc.	Operating	---	---	---	2-3' clay layers 2 synthetic	Collection and detection systems	---	200' below grade	Rock
Bruno, Idaho Envirosafe Services of Idaho	Operating	500' x 500'	At grade mounded	60-70'	---	---	---	---	Rock
Last Chance, Colorado CECOS International/ Browning Ferris	Permitted	150' x 630'	---	35'	3' clay with multiple 80 mil HDPE synthetic liners	Primary collection system and detection system	---	---	Shale

Other Information
- Heap leaching technology. Contract with state to build and operate. - 3:1 slopes clay, synthetic, and soil cap. - Stacked cells, caps form base of second layer of cells. - Impermeable rock foundation. - Closing in near future. ---

APPENDIX III

OPERATIONAL PLAN AND SCHEDULE

III.0 OPERATIONAL PLAN AND SCHEDULE

III.1 GENERAL

Development of the land disposal facility will occur in three phases, including site development, operations, and closure. The site development plan includes all the work necessary before the receipt of the first load of RMA contaminated materials. The operating plan explains operations of the facility during waste placement in compliance with hazardous waste regulations. The site will be restored, monitored, and cared for after site closure according to the closure and postclosure care plan. These plans will ensure compliance with regulations to provide long-term isolation of the RMA contaminated materials.

III.2 SITE DEVELOPMENT PLAN

Site preparation, buildings, utilities, environmental protection facilities, and initial waste cell construction must be completed before the first cubic yard of RMA contaminated materials can be placed in the waste cell. Table III-1 outlines the general sequence of tasks for site preparation and initial waste cell construction. After the first wastes are placed in the first waste cell, the site development is complete. The first waste cell is typically built at the lowest elevation on the site, closest to the runoff control pond and leachate evaporation pond. Upon completion of the work under the site development plan, the operating and closure plans will begin concurrently to minimize the exposed working face and protect waste and cell surfaces from wind and water erosion.

III.2.1 Site Preparation

To prepare the disposal site for waste placement, the site soil and topography must be examined to develop detailed final designs from site survey information. Groundwater monitoring wells will be installed to determine background groundwater quality up- and downgradient to the site. This will provide the means to monitor the regulatory compliance of the waste cells.

TABLE III-1

GENERAL TASKS FOR SITE PREPARATION
AND INITIAL WASTE CELL CONSTRUCTION
(Clean or Support Zone Construction)

1. Monitoring station and wells construction
2. Soil and groundwater background sampling
3. Initial road construction and site survey
4. Clear and grade site
5. Construct berms
6. Install drainage improvements
7. Remove and stockpile topsoil
8. Stockpile clean soil materials for leachate drainage and gas venting, clean final surface
9. Install environmental protection facilities

    a. Leachate treatment and transmission piping from leak detection system
    b. Gas monitoring wells and equipment (optional)
    c. Decontamination facilities
    d. Sanitary sewage and treatment

10. Construct support facilities

    a. Service buildings
    b. Employees' facilities
    c. Fueling facilities
    d. Administration, laboratory, and scales facilities

11. Prepare access roads
12. Install utilities

    a. Electricity
    b. Water
    c. Sewage
    d. Telephone

13. Initial bottom liner installation in waste cell
14. Initial leachate collection system construction in waste cell
15. Construct fencing
16. Quality assurance/quality control slope and subgrade preparation, bottom liner installation, leachate collection installation, and groundwater and soil sampling and analysis
17. Clean construction health and safety requirements

Reference: O'Leary (1986).

With the development of final engineering plans, initial road construction and site clearing and grading can begin. This will involve stripping the top 4 feet of soil. The topsoil will be removed and stockpiled for site restoration. Additional clean, sandy soil will be stockpiled for use in constructing leachate drains and clean final cover grading. Other stripped soils will be used for berm construction.

III.2.2 Buildings and Utilities Construction

While site preparation is being completed, the construction support and environmental protection facilities will be installed. The support facilities include heavy equipment maintenance buildings, employee facilities (including decontamination areas), fueling facilities, administrative, laboratory, and truck scale facilities. These facilities will require access roads and connection for electricity, water, sewage, and telephone. The heavy equipment maintenance garage is shown in Figure 6-5 as a 15,000 square foot building. The employee facilities will include personnel decontamination and clean area equipment storage trailers. The laboratory will be a 400 square foot building for chemical and physical testing of contaminated materials and clean soils. The administration building will be 2,400 square feet in area, to house an employee lunchroom, equipment storage, truck scaling offices, and supervisory, administrative, health and safety, and QA/QC personnel offices. These facilities will support the heavy equipment and the 30 to 60 person construction operation, and may be scaled up or down depending on buildout period.

III.2.3 Environmental Protection Facilities

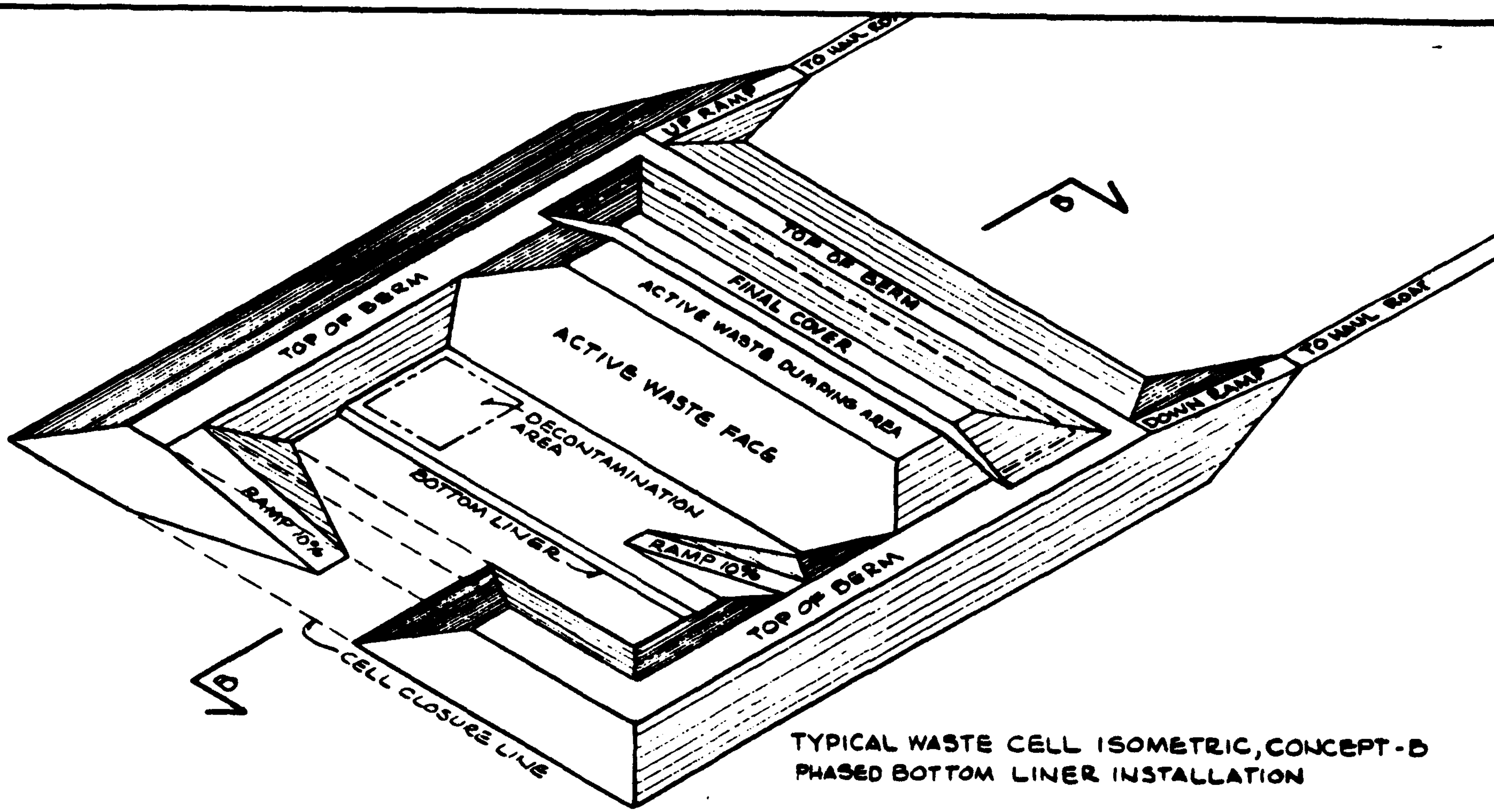
While the site grading and earthen berms are being completed, the drainage improvements will be constructed to control stormwater. These will include runoff ponds and drainage ditches. Other environmental protection facilities will include the leachate treatment pond (evaporation pond) and bottom liner leak detection system to the leachate treatment pond. During operation and postclosure care periods, contaminated runoff will be trucked and pumped into the leachate treatment pond. It is expected that leachate generation will be minimized by maintaining small working faces and practicing rapid placement of the cell cover upon reaching final grade. The leachate pond will be a CERCLA surface impoundment that will meet all pertinent ARARs.

Heavy equipment decontamination water will be trucked to the leachate treatment pond from the mobile truck washing operation at the waste cell decontamination area. A permanent truck washing area near the maintenance area and gate entrance will be available as necessary to supplement the field decontamination operations. The leachate and runoff ponds will be placed at the lowest points of the site to collect stormwater by gravity drainage and leachate by a pump and truck operation.

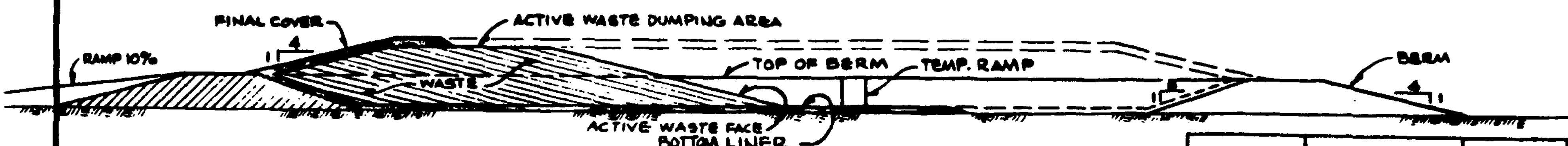
Preliminary air pollution modeling suggests that dust control is a primary concern for the haul roads rather than the site excavations or waste placement. Dust control will require clean water for roadways, which will be stored in water tanks near the front gate. Contaminated water will be drawn from the leachate pond or mobile decontamination facilities in the waste cell for dust control within the waste cell. The working face will be sprayed with this water along with dust suppression agents to minimize the release of contaminant dust during the dry season.

III.2.4 Waste Cell Construction

The earth berms will be constructed of clean subsoil, from uncontaminated areas, primarily stockpiled during the site grading operation, as the first step in waste cell construction. The berm will be placed in controlled lifts to compact the soil to specified density, probably a minimum 90 percent modified Proctor density. For the smaller waste cell (250,000 cy), the berms will be completed with a ramp into the cell before placement of the bottom liner, leachate collection system, and protective drainage layer, as shown in Figure III-1. Where larger waste cells are used, phased berm and bottom liner installation will be used as shown in Figure III-2.

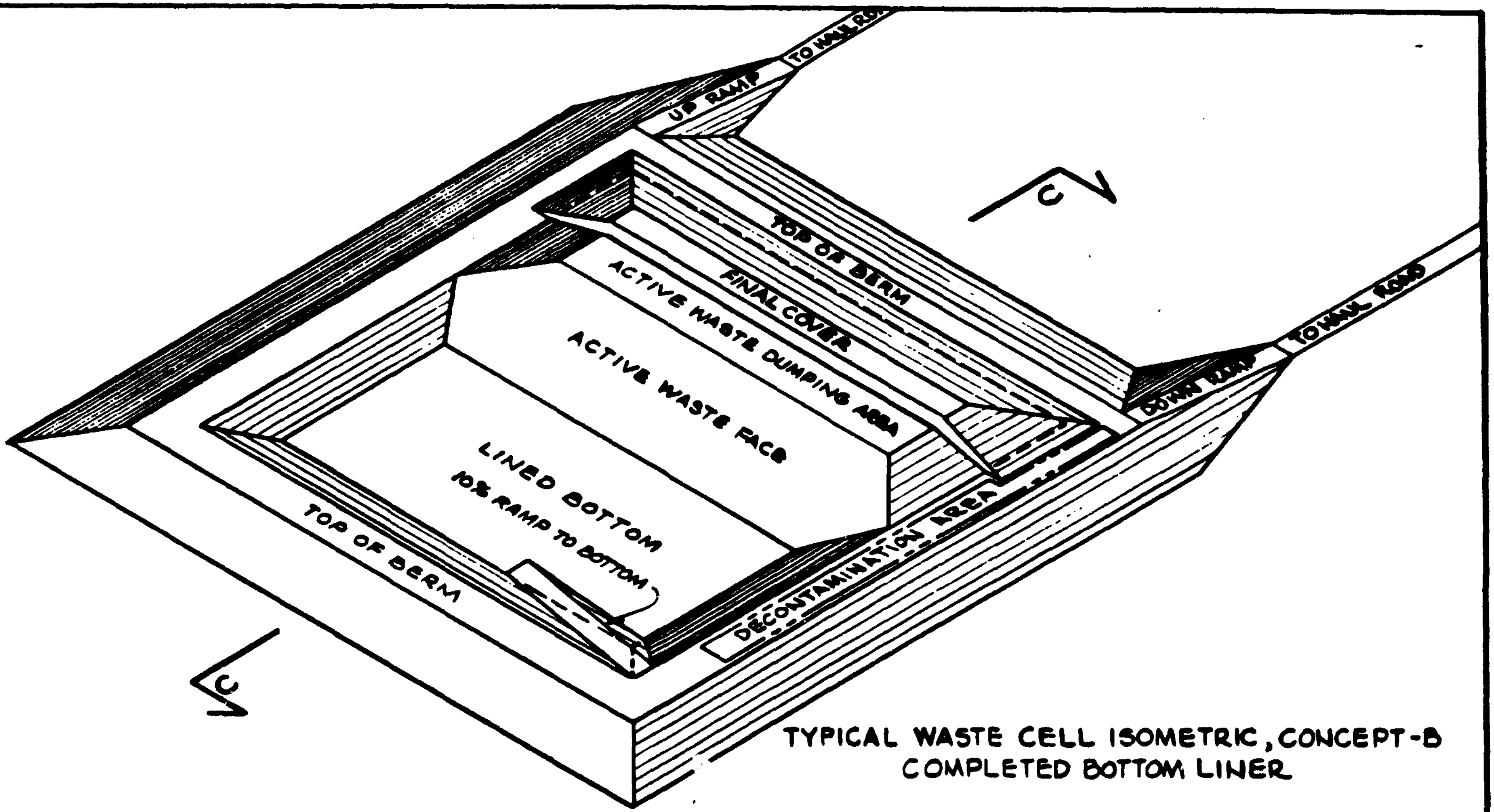


TYPICAL WASTE CELL ISOMETRIC, CONCEPT-B
PHASED BOTTOM LINER INSTALLATION

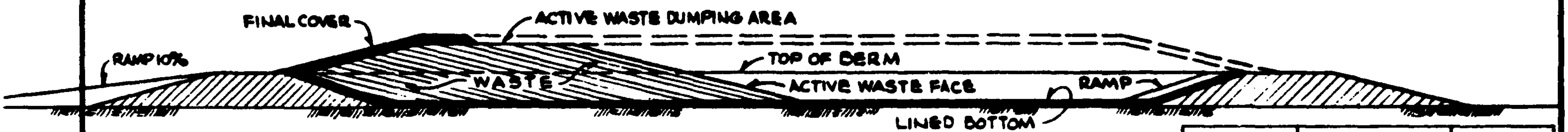


SECTION B

EBASCO	RMA TASK 27	FIGURE III-1



TYPICAL WASTE CELL ISOMETRIC, CONCEPT-B
COMPLETED BOTTOM LINER



SECTION C

EBASCO	RMA TASK 27	FIGURE III-[illegible]

The bottom liner installation will entail placement of a 3 foot soil-bentonite mixture (clay), a 1 foot drainage layer for leak detection, a 100 mil thick high density polyethylene (HDPE) flexible membrane liner, geonet and filter fabric, and 1 foot of sandy, lightly contaminated soil free from stones or sharp objects.

The clay will be placed in thin lifts (6 inches or less) at proper moisture content with proper heavy equipment for compaction. A tamp-foot or sheeps-foot roller will be used to break apart clay or soil lumps and knead the clay together to form a homogeneous layer. Visual control will be used to eliminate unacceptable materials. Density testing will be performed on each lift as the liner is placed. Construction techniques will be developed on test fills to establish lift thickness, number of passes, and moisture, based on testing of clay physical properties in field and laboratory. The clay layer thickness will be controlled by surveying to ensure a proper final surface slope. Hand compaction will be used around leak detection piping and leachate system sumps. The side slope liner will be installed in horizontal lifts parallel to the side slope.

The drainage layer (leak detection system) will be sandy materials placed over the clay liner surface to a carefully measured 1 foot depth. The side walls will be push up slope for placement. The grain size and permeability of the sandy materials, as placed, will be carefully controlled by field and laboratory testing to ensure that the required drainage characteristics are achieved. The same procedures will be followed later for the drainage layers in the cell cover.

The FML will cover the drainage layer. The liner material will be rolled onto the drainage layer with all field seams thermal-welded and tested for leaks. Particular care in installation will be taken at slope changes and sump construction.

No penetrations will be allowed in the bottom liner FML. The leachate collection system consisting of geonet; removal, lateral, and main line piping; and leachate sump will be placed on top of the FML. The geonet will be protected by filter fabric and 1 foot of sandy soil. The leachate removal, lateral, and main collection lines, and leachate sump will be protected by a sand drainage blanket as deep or deeper than the drainage layer. The leachate removal line will pierce the cover liners and rest on top of the bottom liner so that the bottom FML is not pierced by any leachate collection line, as shown on Figure 7-8. Depending on the availability of good quality sandy contaminated material, a clean or contaminated sand drainage layer will be extended over the bottom liner and leachate collection system for additional protection.

When the bottom liner and leachate collection system is installed, the work area will be a clean area so that hazardous waste health and safety issues will be minimized and efficient construction practices will be used. The placement of the first cubic yard of contaminated materials onto the bottom liner will create a contaminated area or contamination zone; safety requirements must be observed and decontamination facilities and a decontamination zone must surround the contaminated area. This will be done to prevent contaminated soil from reaching the support zone or clean area while waste cell construction is in progress.

III.2.5 Quality Assurance/Quality Control

Construction quality assurance/quality control (QA/QC) will be the critical element in site development and subsequent waste cell construction. Construction QA/QC will involve a strong organizational commitment, a detailed construction quality assurance plan, and careful documentation.

Construction Quality Assurance Plan

The audit program or construction quality assurance (CQA) plan is the written approach followed by the owner/operator and his supporting organizations to attain and maintain high construction quality. While the overall content of the CQA plan will depend on the site-specific nature of the facility, at a minimum the plan should include: 1) areas of responsibility and lines of authority in executing the CQA plan; 2) qualifications of personnel; 3) types of observations and tests to be performed; 4) design of a sampling plan, including sampling frequency, acceptance/rejection criteria, and corrective action procedures; and 5) documentation procedures and recordkeeping.

The inspection program of construction quality control (CQC) will consist of the active inspection of ongoing activities. These inspection will include: 1) on-site observations of the work in progress to assess compliance by the contractor with the plans, specifications, and construction-related contractual provisions for the project; 2) field and laboratory tests; 3) reports to the CQA officer of the results of all inspections, including work that is not within contractual quality or fails to meet contract requirements; 4) monitoring of reviews and tests conducted by the contractor as required by the construction specifications and contract; and 5) verifying that tests, equipment, and system startups are conducted by qualified personnel and proceed according to standardized procedures defined by contract documents.

The effectiveness and ultimate success of the hazardous waste land disposal facility will depend on the qualifications and performance of the personnel. The CQA officer should possess a degree in engineering, professional registration, and sufficient practical experience in land disposal facility construction and construction site experience to demonstrate expertise for the successful implementation of CQA-related activities. The inspectors should also have degrees in engineering and enough practical experience in construction inspection to be familiar with specific practices in the field relating to construction techniques, codes, and regulations regarding material and equipment installation, site safety, and testing. Technicians responsible for sampling and testing need only be qualified to perform those activities; however, no work should be allowed without the presence of an inspector qualified as described above.

The CQA plan will specify that after completing the various facility components, CQA/CQC personnel will conduct a final inspection, including completion tests, to make certain that each component was installed according to design specifications.

Upon completion of the project, a final documentation report will be prepared and a copy retained in the facility operating record. This report will include summaries of all construction activities, observation and test data sheets, problem reporting and corrective measures data sheets, block evaluation reports, deviations from design and material specifications, and as-built drawings.

Documentation

Documentation in support of the CQA/CQC program will be carried out throughout the construction and post-construction period. Standard reporting procedures will include daily preparation of field data sheets. These data sheets will include such information as the date, weather conditions, construction operations in progress, the location and results of CQA/CQC tests conducted, description of any problems encountered, corrective actions, and the signatures of responsible personnel. A daily summary report will be used to provide the chronological framework for identifying all other reports.

Grain size analysis and compaction testing are important to control proper disposal site foundation construction and sub-base preparation. Much of this work will occur during site preparation. A sample grid will be prepared based on identification of different soil classifications encountered at the disposal site. The foundation soils will be compacted to 90 percent of the modified Proctor density or the in-place density of the surrounding soils.

Installation of the bottom liner and leachate systems will require documentation of the following parameters (Fowler, 1986).

Clay Liner

- o Density testing (including as placed moisture content)
  - 100 foot grid spacing per 1 foot thickness
  - Offset grid pattern in each lift
  - Greater testing frequency in confined area

- o Moisture density (Proctor) curves
  - Every 5,000 cy or less
  - Each major soil type
  - Five point curve
  - Modified Proctor density

- o Grain size analysis (including Atterburg Limit)
  - One test per acre or smaller area
  - Sieve to 200 mesh
  - Hydrometer beyond 200 mesh to 2 micron

- o Lab hydraulic conductivity
  - Performed on every third grain size sample
  - Undisturbed sample (Shelby tube)
  - Falling head
  - Optional use of contaminated groundwater to simulate leachate

- o Survey control
  - 100 foot grid
  - Preliner placement
  - Post-liner placement

Drainage Layer

- o Grain Size
  - One test per 1,000 cy material placed
  - Minimum four samples
  - Test to 200 mesh

- o Lab Permeability
  - One test per 2,500 cy of material placed
  - Remolded to in-place density
  - Permeability test with optional use of contaminated groundwater

Flexible Membrane Liner

- o Test seams (factory and field); one field test sample per acre or less
- o Leak test all continuous seams

Leachate Collection System

- o Bedding material one grain size per 1,000 linear feet of trench, with a three-test minimum

- o Check invert elevations of pipes, sumps, and manholes
- o Check trench and line locations
  - Ensure that photographs are taken of anti-seep collars, manhole connections, and sump connections
- o Leak test manhole and leachate line to leachate pond
- o Clean out leachate lines

The preceding tests and documentation will be supplemented by photographic records and log books for each waste cell.

III.3 OPERATING PLAN

The general tasks for site operations and new waste cell construction are presented in Table 9-2. These tasks support ten work items for the operating plan as follows:

- o Waste Cell Construction - This work item describes waste cell construction that continues after site development.
- o Waste Control - The analyses of waste chemical and physical characteristics are done to inventory wastes, improve waste compaction, and separate incompatible wastes.
- o Waste Cell Operations - The timing and methods from the waste excavation to placement of waste.
- o Equipment and Maintenance Requirements - This item describes the heavy equipment and maintenance required to excavate load, haul, and place the contaminated materials and liner materials.
- o Personnel Requirements - These are a function of the waste operations, QA/QC, health and safety, and training needs for the buildout period.

TABLE III-2

GENERAL TASKS FOR SITE OPERATIONS IN WASTE CELL AND CONSTRUCTION OF NEW WASTE CELLS

1. Repeat tasks 3 through 8, 13, 14, 16, and 17 from Table 9-1 for new waste cell construction.

2. Waste excavation and transportation

   a. Load and cover truck
   b. Decontamination of truck
   c. Transport to waste cell working face

3. Waste control inventory and sampling

4. Waste placement

   a. Unload truck at waste cell working face
   b. Spread onto fill and compact
   c. Map position in cell of all waste placed to document waste control

5. Haul truck and waste cell personnel decontamination on leaving active waste cell area

6. On reaching final grade for waste, clean drainage layer installation

7. Initial cover installation and drainage modification

8. Initial waste cell site restoration

9. Leachate removal, transport, and disposal

10. Stormwater management system operation

11. Site monitoring

    a. Leak detection
    b. Groundwater and gas monitoring wells
    c. Leachate sumps
    d. Stormwater

12. Quality assurance/quality control - slope completion, cover installation, waste placement and compaction, and groundwater and soil sampling

13. Health and safety waste excavation, transport, placement, and personnel monitoring for contaminated areas operations

Reference: O'Leary (1986).

- Environmental Controls - These are applied to stormwater, leachate, gas and dust, and noise.

- Site Monitoring - This involves primarily monitoring environmental control activities and inspection of site construction.

- Emergency Response - This provides for the contingencies associated with unexpected events such as a fire, explosion, or liner failure.

o

Quality Assurance/Quality Control - The QA/QC procedures control the successful installation of waste cells to ensure waste containment.

- Health and Safety - These aspects include use of the proper personnel, correct protective equipment selection and use, and the work flow from the support zone (clean area) to decontamination and contamination zones for waste placement.

III.3.1 Waste Cell Construction

The waste cell construction will be divided into three parts. The first will be the continuation of construction of the bottom liner and leachate collection system for new waste cells. The next part will be the waste operations and fill progression from initial waste placement to final grade, as shown in Figure III-1. The third part will be the cover system placement that closes up the waste cell.

The bottom liner and leachate collection system construction are described in Section 9.2.4. This activity is ahead of waste placement so that liner material can be placed in a clean area or support zone. Two basic bottom liner and leachate collection systems construction approaches could be used, the phased approach or complete installation approach.

During phased waste cell construction, the bottom liner and leachate collection system will be placed from the lowest to the highest ends of the waste cell. These systems will be connected in phases so that the waste cells can be completed in more than one construction season if necessary. This approach will leave a minimum exposed working area. The placement sequence will ensure that contaminated runoff will always be contained during the phased construction of the waste cell bottom liner.

With a complete bottom liner and leachate collection system installation, there will be more exposed area for leachate production because the fully installed bottom liner system acts like a bathtub. However, the smaller waste cell sizes (less than 1 million cy) may be best installed as one unit because of the small exposed working faces and to minimize traffic and equipment congestion.

Easte placement will begin with as small a working face as possible in order to control waste compaction. The wastes are primarily soils that can expand as much as 15 percent after excavation. The soils will be compacted to reduce post-closure subsidence and associated settling problems with the cover.

The working face will become a contaminated area or contamination zone. A decontamination zone will surround the contamination zone so that personnel and equipment can be decontaminated before leaving the working face for the clean areas.

When the final grade for waste placement is reached, a clean drainage layer will be placed above the waste before final cover installation begins. This layer will drain contaminated runoff from the top of the fill to the leachate collection system during construction of the waste cell.

The final cover will be placed as rapidly as possible to reduce the area for contaminated runoff production in the active waste cell. The cover installation will be similar to the bottom liner installation; however, care must be taken in the clay liner placement to prevent its contamination. This will be done so that subsequent cover liner and drainage layers can be installed as a clean zone activity. The final cover installation progresses across the final grade as the waste cell will be filled until the waste cell is covered as shown in Figure 9-1.

The waste cell construction process will be repeated until all the contaminated sites at RMA are cleaned up and the waste cells filled.

III.3.2 Waste Control

Waste control activities will include mapping the location of wastes in the waste cell, controlling the combination of wastes to minimize contaminant releases, and estimating the compacted volume of wastes. Waste cell mapping will provide a location and elevation map and inventory of where the contaminated materials are to be placed in the waste cells. This mapping will require a waste analysis plan with accurate field surveys of waste placement; accurate haul truck weights; and representative estimates of the compacted density of contaminated material.

A waste analysis plan will be developed to address the issues of waste control and will incorporate:

- General and specific requirements as specified in 40 CFR 261, 264, 268, and other Federal/state.
- Methods for addressing landfill disposal restrictions.
- Preacceptance chemical testing results to separate incompatible wastes.
- Representative sampling and QA/QC procedures for the RMA indicator contaminants or other substance lists from the regulations (such as 40 CFR 261.11 Appendix VIII or CERCLA hazardous substance lists).
- Determination of physical tests or estimation practices for bank volumes, loose volumes, and compacted volumes of contaminated materials at RMA sites as required for planning purposes.

- Results of waste leachability tests followed by waste-to-liner compatibility testing for contaminated materials with high total organic carbon (TOC) or total organic halogen (TOX) content leachates (greater than 10,000 ppm TOC or 1,000 ppm TOX).

- Testing procedures for spill identification, stormwater, and groundwater control analyses, leachate treatment analyses, dust control, and other air monitoring.

- Frequency of testing, type of sampling, and data evaluation for waste analysis plan.

The construction sequence worked out on the basis of this testing will ensure incompatible wastes are not placed together, as described in Section 3.6.2, Waste-to-Waste Compatibility.

Settlement will be controlled by proper waste compaction and limited placement of building debris in any one waste cell. Small quantities of building debris or bulky wastes are expected to be placed in the center region of the waste cell (approximately 0.5 to 5 percent building debris per waste cell). Minimum settlement will ensure the integrity of the waste cell cover (the top barrier is not breached or the drainage pattern disturbed as a result of differential settlement).

III.3.3 Waste Cell Operation

Waste cell operations will consist of three primary actions. The first action will be the excavation or demolition of contaminated materials at RMA. These contaminated materials will then be hauled to the working face of the land disposal sites. The third major action will be the placement of waste in the waste cell. These operations will continue until the waste cell is filled to its final grade.

Excavation or demolition work will continue until concentrations of indicator compounds at RMA sites meet designated clean levels. The site excavations will be performed using large bulldozers and loaders. Bulldozers will windrow contaminated soils for loading into haul vehicles. For deep contaminated sites (greater than 20 feet), a dragline may be used for contaminated soil excavation. A backhoe or power shovel may be used to excavate contaminated material from small sites or "hot spots" (i.e., small, heavily contaminated areas). The building demolition area could use a variety of demolition equipment (wrecking balls, cranes, fork lifts, and loaders). Whether by excavation or demolition, site cleanup operations will minimize contaminant migration from the contamination zone by decontaminating personnel and equipment leaving the contamination zone. Surface water runon will be controlled to avoid contaminated runoff. Dust suppression measures will be applied as required.

Wastes from excavation or demolition of RMA sites will be loaded into off-road dump trucks and covered before transport to the land disposal facility working face. The loading operation will be in the cleaned portion or lightly contaminated areas of the contamination zone. The trucks will have their wheels and undercarriages steam cleaned, as required, in a decontamination zone surrounding the site contamination zone before hauling the site wastes to the waste cell. Paved roads will be used to minimize dust for the anticipated year-around waste removal and hauling operation.

The third waste cell operation will be the placement of waste. Unlike land disposal facilities excavated for underground waste placement, the facilities will be above-ground level. Waste placement will begin at the lowest point of the bottom liner, inside the waste cell berms.

Phased Cell Construction Method

The phased cell construction method is shown in Figure 9-2. Two ramps are required, one for waste placement and one for waste cell construction. The first year, waste trucks will use the waste placement ramp at the middle of the waste cell and the next year the back end ramp. The waste placement would be parallel to the sawtooth leachate collection system, so that the sawtooth can provide some isolation of the contamination zone, from the decontamination zone in the bottom of the waste cell between the contamination zone and decontamination zones. The waste could be push up slope for the first two-thirds of the waste cell; an area lift method will be used to work the waste lifts up to grade in the ramp-up area. This waste placement technique will be utilized to minimize the exposed working face and to support phased cover operations. At the proper time, the decontamination zone will be moved outside the waste cell to the top of the back ramp in a paved and lined decontamination area. In the back end of the waste cell ,as horizontal area lifts are built, bulky waste and building debris will be placed near the berm height in the center of the waste cell to prevent liner puncture and to control differential settlement from too much bulky waste or building debris in any one location. Building materials will be placed so that voids will be filled to prevent settlement.

If there are idle periods between construction seasons for the large waste cell, there may be large exposed areas of waste at final grade. An intermediate sand cover will be installed to reduce contaminant migration and to connect the stormwater runoff from the unfinished final grade to the leachate collection system. Waste placement is anticipated throughout the year, weather permitting, and the exposed working face will be minimized during operations.

Completed Cell Construction Method

The completed cell construction method is shown in Figure 9-1. Only one ramp will be used to place waste in the waste cell. The decontamination area will be at the top of the ramp. Waste can be placed in horizontal lifts across the entire bottom of the waste cell because of the smaller waste cell size and shorter duration of waste exposure to precipitation.

The advantage of the completed cell construction method is the completion of a waste cell from construction to final cover in one construction season.

While more exposed area may exist from the use of an area filling technique versus an inclined face technique, waste compaction is simpler, and less potential contaminated runoff generation is expected with this technique.

The completed cell construction method can mean seasonal employment with a skeleton crew of inspection, laboratory, and QA personnel. Winter waste placement is not always desirable because of the risk of freeze-thaw problems with the exposed clay bottom liner unless substantial protection is provided.

III.3.4 Land Disposal Equipment and Maintenance

A land disposal operation that requires the movement of 16 million bcy from cleanup sites as much as 2 miles to the on-site disposal facilities will require careful attention to earth-moving equipment selection. At a concept design level, the daily waste handling volume, haul distances, waste cell size, and liner systems will be used to establish the equipment needs for waste cell construction, waste cell operations, and miscellaneous support equipment.

Waste cell construction will require the development of 10 to 100 acres per year, with an anticipated average of 40 to 60 acres per year over a ten year buildout period. The disposal site must be cleared of top soil and the site graded. This operation will require motorized scrapers, large bulldozers, loaders, and off-road dump trucks. Construction of access roads, waste cell berms, top soil stockpiles, clean sand borrowing operations, and bottom liner installation will also require this equipment, plus sheepsfoot rollers and road graders.

Waste cell operations will excavate or demolish, haul, and place approximately 400,000 to 2,500,000 bcy per year of waste, with an average of 1.5 million bcy per year for a 10 year buildout. Therefore, more than a half dozen types of equipment will be operating simultaneously on-site, with 20 to 60 pieces of earth-moving and demolition equipment supporting site cleanup activities. This equipment can include:

- Bulldozers to windrow near-surface contaminated soil, build waste cell lifts, and demolish small structures.

- off-road dump trucks.

- Draglines to excavate sites with deep soil contamination.

- Backhoes for small-site excavation and to load demolition waste.

- Scrapers for placing clean soil.

- Sheepsfoot rollers to compact contaminated soil in the waste cell.

- Wrecking balls, cranes, and fork lifts for demolition work.

This could mean 20 to 60 pieces of earth-moving and demolition equipment operating to support the site cleanup activities.

To support waste cell construction and waste cell operations, there will be maintenance equipment for roads and vehicles, fueling vehicles, personnel transport vehicles, pug mill equipment, decontamination equipment, special demolition equipment, and utilities support equipment.

This equipment can include:

- Road graders, street sweepers, and water trucks for road maintenance and dust control.

- Tire trucks, tow trucks, and fueling trucks to support heavy equipment operation.

- Pickup trucks to transport supervisory, health/safety, QA/QC, and operating personnel around the site.

- Pug mill for soil/bentonite mixing.

- Steam cleaners for decontaminating tires and undercarriages of vehicles leaving the contamination zone for the support zone.

- Sump pumps, fuel storage pumps, fire fighting equipment, water pumps, and water treatment equipment for utilities support.

This equipment will be housed and/or maintained in a 15,000 square foot heavy equipment maintenance building. The building will have a maximum of a month fuel supply and a two day water supply.

A maintenance program for the land disposal facility equipment will be established either by specification requirements in the final design or by contractual obligations for leased equipment by the general contractor for waste cell construction and waste cell operation. It is common to have as much as 10 to 15 percent of land disposal equipment in maintenance at any one time for a large disposal operation. This is due primarily to the severity of the working environment and equipment operations. This maintenance cost can be 5 to 20 percent of annual operating cost, depending on the items included.

III.3.5 Personnel Requirements

Site cleanup and disposal operations are expected to require 30 to 100 workers. These workers are required for the following functions:

- Supervisory personnel, including site manager, foreman, and laboratory, health and safety and QA/QC managers.

- Laborers for heavy equipment operations and maintenance.

- Technical staff (laboratory personnel, waste samplers, field QA/QC, and health and safety inspectors).

- Administrative personnel (recordkeeping, training, and security).

III.3.6 Environmental Control

Environmental controls will be required for the three primary contaminant migration pathways: stormwater, leachate, and dust. As stated in the waste cell operations section, the active working face and exposed waste areas will be minimized to reduce leachate, dust, and contaminated stormwater with either the phased or completed cell construction methods.

Stormwater control will be required at the cleanup of individual sites and at the waste cell operations. At the site cleanup, excavation will be conducted from the highest to the lowest portion of the site. Temporary upland drainage may be required to reduce stormwater run on. Any contaminated equipment will be decontaminated before moving off-site to the waste cell. The clean site will be backfilled, regraded, and revegetated to control stormwater.

The land disposal site will require the following stormwater control system:

- Stormwater detention pond;
- Stormwater treatment (carbon absorption for contaminated stormwater);
- Stormwater drainage ditch system constructed from the lowest to highest portion of the site; and
- Final cover placement and waste cell revegetation while waste cell operations progress (estimated to involve 40 to 60 acres per year).

The operational performance of this system will be inspected to ensure stormwater control, as described in Section 9.3.8.

The leachate control system is described in Chapters 6 and 7. The system will incorporate a number of features that will improve its operation:

- There are to beno barrier penetrations in the bottom FML. The leachate generated during waste cell installation will be pumped out through the cover.
- The sawtooth leachate collection system running the length of the cell will be relatively easy to clean out and inspect. It will also improve the separation of the decontaminated zone and support zone.

- Leak detection in the cover will allow earlier identification and repair of leaks to keep water out of the waste cell.

- Placement of additional soil material over the bottom liner will protect it from damage and reduce leachate generation.

The leachate control system will be operated by inspecting and pumping out leachate sumps to leachate tank trucks for transport to leachate treatment facilities. Leachate will be evaporated. No leachate generation and very limited contaminated runoff is to be expected during active filling, and even less during the post-closure care period and beyond. The leachate system performance will be checked by the leak detection system, leak detection devices (moisture detectors), and groundwater monitoring wells, as described in the site monitoring plan, Section 9.3.8.

Dust control will involve the use of water and/or dust suppression chemicals; vehicle decontamination procedures; use of paved roads and the cleaning of these roads; rapid revegetation of cleanup sites and disposal areas; and shut down of operations during high wind conditions (greater than 35 mph).

During the summer months, water be used to control dust at RMA sites and the disposal operation. Vehicle tires and undercarriages will be steam cleaned, as required, before leaving the contamination zones at RMA sites and the disposal facility. This operation will reduce the need for street sweeping of the paved road to control dust in the construction season. Other operational controls for high winds and rainfall will be used to further support the preceding activities. Additionally, sites will be revegetated rapidly to further minimize fugitive dust emission. Site monitoring will be used to ensure acceptable air quality.

III.3.7 Emergency Response Plan

The operating plan will include preparedness, prevention, and contingency plans for emergency response. The preparedness and prevention plans will include equipment, access to communication devices, and access of personnel and equipment through the area. The equipment will include intercoms, alarms, two-way radios and base station, telephones, fire protection equipment and supplies, and emergency power.

The contingency plan will be developed for the following events:

- o Fire/explosion
- o Spill or release of material or waste
- o Flood/precipitation event
- o Loss of electrical power
- o Leak detection system contamination
- o Unknown and uncontrolled reactions

Notification and contingency plan implementation procedures will be developed for both the site cleanup and disposal site areas.

Th plan will include the following items, as specified in 40 CFR 265:

- o Procedures to be followed for fire, spills, explosion, and other uncontrolled releases;

- o Procedures to be followed for flood/precipitation or loss of electrical power events;

- o Procedures to be followed for exceeding concentration limits in daily uncontaminated runoff samples of or escape of contaminated or potentially contaminated runoff from the facility;

- o Procedures to be followed for discovery of contaminated groundwater within or outside the facility compliance boundary;

- o Procedures to be followed for discovery of hazardous constituents in a waste cell leak detection sump;

- Procedures to be followed if hazardous constituents are identified in detection sump;

- Reporting requirements;

- Emergency coordinator availability;

- Amendment of contingency plan;

- Copies of contingency plan;

- Arrangements; and

- Emergency response training for outside agencies.

III.3.8 Site Monitoring

The following regulatory requirements, as specified in 40 CFR 264, apply:

- The groundwater monitoring program must include a determination of the groundwater surface elevation each time groundwater is sampled.

- The unit must be inspected weekly and after all storms to ensure that systems are still in place and working correctly.

The effectiveness of the design must be evaluated periodically to ensure that the land disposal facility is meeting the two principal objectives of providing waste containment and preventing contaminant generation and migration. The evaluation will be accomplished through a monitoring program for: flowing or standing water in the primary leachate collection system piping or sumps; the presence of leachate in the leak detection systems; the presence of contaminated groundwater or surface water; the presence of contamination in soil and plants; and the presence of contaminated dust particles and hazardous gas emissions in the air.

The well monitoring system incorporated into the facility design will provide the means of monitoring the groundwater in accordance with closure and post-closure plans developed for the facility. Plans are to be prepared in compliance with the previously described regulations. The prescribed inspections will ensure that the physical features of the facility are in satisfactory operating condition.

III.3.9 Quality Assurance/Quality Control

The QA/QC program for operations is to be similar to that for construction. All waste placed in the cells must be mapped as to location, traceability established to the point of origin, and all samples and tests performed on the waste. The QA/QC program will conform to the EPA Technical Guidance Document, Construction Quality Assurance for Hazardous Waste Land Disposal Facility - EPA/530-SW-01, 1986.

III.3.10 Health and Safety

This section will discuss work zones; Level B protection for heavily contaminated site cleanup; vehicle and personnel decontamination requirements; special modifications to earth-moving equipment to operate in Level B; health and safety plan development.

Work zones are an important concept for both site cleanup and land disposal operations. There are three basic work zones: contamination zone, decontamination zone, and support zone. The contamination zones are within the site cleanup boundaries, where contaminated materials are excavated or demolished, and within the waste cell where wastes are placed. The decontamination zone is a transition zone between the contamination and support zones. This zone is for decontaminating personnel and equipment leaving the contamination zone for the support zone. The support zone is a clean area where support materials and equipment are stored. The work zone concept will be used to minimize the migration of hazardous substance away from the site cleanup and disposal areas.

The use of Level B protection for site personnel is anticipated for the heavily contaminated sites (e.g., Basin F). This level of protection means use of self-contained breathing apparatus and protective clothing, up to complete enclosure of the worker. Personnel protection clothing and equipment can restrict sight and movement with significant loss of worker productivity. To minimize worker productivity losses with Level B protection, the operating equipment will be modified. The heavy equipment operators will be enclosed in either a self-contained equipment cab with air conditioning and supplied air, or a modified cab with air supply and Level A protective clothing, and mobile air supply and lines to reduce potential heat exhaustion.

For lightly contaminated sites and disposal operations, lower levels of personnel protective clothing and equipment will be used.

In either case, personnel and equipment will be decontaminated before moving materials from the contamination zone to the support zone. The selection of decontamination solutions is defined in the Health and Safety Plan. These decontamination procedures for both personnel and equipment help ensure minimum contaminant migration from the cleanup sites and the waste cells.

A Health and Safety Plan will be developed in the detailed design phase to assist the cleanup and waste cell operation contractors in protecting their workers. A health and safety manager will administer the construction contractors' health and safety plan development. The plan will cover, at a minimum, site safety procedures as well as the following items:

- Identification and description of site
- Identification of hazards
- Development of hazard reduction plans
- Selection of personnel protective clothing and equipment

- Selection of personnel and equipment decontamination procedures

- Identification of chain-of-command and responsibilities

- Development of emergency response plans

This plan will also address how maximum excavation production will be achieved by a clear statement of cleanup levels, the extent of contamination for excavation and demolition, and the use of hazard reduction plans, particularly for demolition work to downgrade personnel protective equipment and clothing level of protection.

III.4 SITE CLOSURE AND POSTCLOSURE CARE PLAN

III.4.1 Final Site Restoration

Final site closure will include activities such as the decontamination and restoration of roads, stormwater detection pond, temporary support structures, placement of riprap and soil over leachate pond, and placement of site identification monuments.

The placement of final cover on the last waste cell will occur after proper decontamination procedures are accomplished on roads, equipment, temporary support structures, and stormwater detention pond. The waste from this final decontamination procedure will be placed in the last waste cell. The decontamination wastewater will be placed in the leachate treatment pond.

After the post-closure care period, the leachate treatment pond will be modified to act as a drainage field for the leachate from any failed waste cell. Riprap and soil will be placed over the leachate treatment pond with the surface revegetated.

Upon completion of the post-closure care period, each waste cell will have a site identification monument installed. This monument will provide site identification in formation to alert future land use planners about this area.

III.4.2 Site Monitoring and Post-closure Care

The closure and post-closure care for a hazardous waste landfill will involve the development of closure and post-closure care plans. Within these plans, closure performance is measured by two criteria. These criteria are to minimize the need for further maintenance and to prevent threats to human health and the environment. Within 90 to 180 days of the completion of operation, final closure will be initiated unless the process necessitates a longer time period. Following final closure, the site will function with minimum maintenance.

The post-closure care plan will provide the following guidance to the owner and operator of the facility:

- The integrity of the final cover must be maintained by making necessary repairs to the cap required as a result of settlement, subsidence, erosion, animal intrusion, or other events.
- Maintain and monitor the leak detection system where present.
- Operate leachate collection and removal systems until leachate is no longer detected.
- Maintain site vegetation to prevent deep rooted plants from becoming established.
- Monitor and maintain a groundwater monitoring system.
- Prevent erosion or damage from runon and runoff.
- Protect and maintain survey benchmarks used to comply with regulations on land use identification.
- Report leaks in leak detection system to appropriate authorities.

Another element of the post-closure care period and beyond will be the use of the property. RCRA regulations, Subpart G, 40 CFR 264.117, Postclosure Care and Use of Property, describe post-closure use of property. Where hazardous wastes remain after closure, a land use must never be allowed to disturb the integrity of the final cover, or other components of the containment system, or the function of the facility's monitoring system, unless the EPA Regional Administrator approves the proposed disturbance. If the proposed land use would disturb the site, the Regional Administrator judges whether the disturbance:

- Is necessary to the proposed land use of the property and will not increase the potential hazard to human health or the environment; or

- Is necessary to reduce a threat to human health or the environment.

Other requirements of the owner include the following:

- The owner or operator must inspect his facility for malfunctions and deterioration, operator errors, and discharges that may cause, or lead to: 1) release of hazardous waste constituents to the environment; or 2) a threat to human health (40 CFR 264.15).

- An owner/operator will provide continuing operation and maintenance of the leak detection systems during the active life of the unit, the closure period, and the post-closure period (40 CFR 264.90).

- The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that: 1) represent the quality of background water that has not been affected by leakage from a regulated unit; and 2) represent the quality of groundwater passing the point of compliance (40 CFR 264.97).

III.4.3 Quality Assurance/Quality Control

These requirements are similar to those described in Section 9.3.9, except that barring possible failures, there are less activities to document during closure and post-closure periods.

Of particular concern during the post-closure period is the integrity of the closed waste cell. The following systems would be monitored over this post-closure period to verify the performance of the waste cell during this period:

- o Waste Cell Leak Detection System Monitoring
  - Semi-annual cover system monitoring to initiate cover repair as necessary.
  - Semi-annual bottom liner system monitoring to initiate waste cell repairs with leachate collection or complete removal of the waste cell, as necessary, with leachate in the bottom liner leak detection system.
- o Leachate System Leak Detection System Monitoring
  - Same as waste cell bottom liner leak detection system monitoring.
- o Semi-annual groundwater monitoring to ensure contaminant migration past the waste management unit boundary in the post-closure care period.

Waste cells that pass through this period without contaminant release will be examined on a less frequent basis. Waste cells that fail to pass through the post-closure period without a release will be repaired or replaced, and the post-closure care period extended until the waste cell is demonstrated to be free from contaminant releases.

III.5 SCHEDULE

The total buildout period for the facility can vary depending on a number of factors, such as construction economy and the target date for completion of RMA cleanup. The first and last years are allocated to construction of facilities and closure activities, respectively, with the waste excavation, transport, and placement occurring entirely in the period between first and last years.

In the following Appendix, buildout periods of 5, 10, 20, and 30 years are examined and cost estimates displayed for each. These periods include the first-year facilities' construction and the final-year closure activities.

Cells built by phased construction will be started in the spring. Should the climate require a halt in construction during the winter, construction will continue until enough waste volume capacity is built to last until the next construction season. Upon reaching grade, final cover will be installed. In the fall, final cover and waste cell construction operations will be secured for the winter if necessary. Waste placement would continue on a year-round basis.

An annual construction cycle would consist of building, filling, and covering an entire waste cell in one construction season from the spring to fall. This type of operation may be applied to the smaller waste cell sizes (e.g., less than 1,000,00 ccy). A skeleton crew will be kept on-site through the winter months to monitor the site, to maintain equipment and records, and to review the next construction season's site cleanup activities and operating plans.

APPENDIX IV

COST ESTIMATE DETAILS

Rocky Mountain Arsenal - USAT 5658.784 TASK 27
Ebasco Services Inc.
Estimate of Waste Transportation Costs for a 5 Year Buildout Period

Notes:

Waste transportation costs are estimated in two parts: Haul costs (Table 2) and Loading/unloading costs (Table 3).
Waste Transportation Costs to sites 1 and 6 (Summation of tables 2 and 3) are presented in Table 4.
The first and last years of the buildout period are used for facility construction and closure, respectively.
Loading/unloading costs are uniform throughout the buildout period.
Equipment production rates are based on 50 minute hours (83% efficiency).
Equipment production rates were estimated from the 12ed. of the Caterpillar Performance Handbook.
Equipment costs are based on an hourly rental fee that includes overhead for a driver, a mechanic, fuel, maintenance and spare parts.
Rental costs include a discount for both a volume fleet and long term rental agreement.
Equipment rental costs were provided by EBASCO Constructors Inc.

HAUL COSTS

Haul costs are considered to be costs associated with the transportation of waste from the contamination site to the land disposal facility.
Haul costs are calculated individually for sections.
Waste volumes in sections were taken from the DMLF or the Phase 1 Contamination Assessment Reports if available.
Table 1 provides an estimate of the fleet size and time required to transport waste from sections to disposal sites 1 & 6.
Haul distances were measured from the center of "sections" to the centroid of the disposal site via the existing road grids.
Haul costs depend on haul distances and thus vary over the buildout period.
Waste material is transported in end dump haul trucks (off-road size).
A summary of haul costs by sections are presented in table 1 for both sites 1 and 6..
The annual "haul costs" for transportation of waste material is presented in table 2.

Equipment Specifications

End dump haul truck (Caterpillar 769C, p.226)

Empty vehicle weight (EVW)	= 68,000lb
Gross vehicle weight (GVW)	=138,000lb
Payload	= 70,000lb or 35 tons
Capacity	= 22.8 cy (struck)

Estimation of haul truck production rates

Haul truck production rates are a function of the travel time to and from the contamination site and land disposal facility.
The total round trip travel time is the sum of the haul time, return time and load/unload time.
The haul times and return times can be estimated by equations 1 and 2 derived from the Caterpillar Handbook (p.233-234).
The load/unload time is an assumed constant.

Eq. (1) Haul time (min) = 0.22 + 4.81E-4(X) were X is in feet, based on the GVW and a total resistance of 4% (2% rolling + 2% grade)

Eq. (2) Return time (min) = 0.24 + 2.50E-4(X) were X is in feet, based on the EVW and 0% total resistance (2% rolling and -2% grade)

Input parameters for calculation of Table 1 and 2.

Waste placement years=	3.5	
Construction days per year=	260	(5 days/week-52 weeks/year)
Hours per day=	16	
Begin waste placement at end of year	1	
Load/unload time (minutes)=	2.15	
Hourly 769C rental fee ($)=	68.79	
Annual waste placement rate (BCY)=	3,810,057	

TABLE 1
Required fleet size for Transportation of waste
to sites 1 and 6

CLEAN UP PRIORITY	SECTION NO.	WASTE VOLUME (BCY)	HAUL DISTANCE SITE 1D	HAUL DISTANCE SITE 6	HAUL TIME (MIN) SITE 1D	HAUL TIME (MIN) SITE 6	RETURN TIME (MIN) SITE 1D	RETURN TIME (MIN) SITE 6	TOTAL TRAVEL TIME SITE 1D	TOTAL TRAVEL TIME SITE 6	PRODUCTION RATE(BCY/HR) SITE 1	PRODUCTION RATE(BCY/HR) SITE 6	REQUIRED FLEET SIZE SITE 1	REQUIRED FLEET SIZE SITE 6	YEAR OF CLEAN UP SITE 1 OR 6
1	26	3,996,000	3,100	16,800	1.71	8.30	1.02	4.44	5.15	16.15	179.45	57.17	5	16	1
2	36	3,630,700	7,300	11,560	3.77	5.78	2.09	3.13	8.58	11.94	107.57	77.33	9	12	2.049
3	1	2,185,800	13,700	15,840	6.81	7.84	3.67	4.20	13.66	15.38	67.60	60.04	14	15	3.002
4	2	1,715,800	13,700	22,120	6.81	10.86	3.67	5.77	13.66	20.42	67.60	45.21	14	20	3.575
5	25	47,300	2,100	11,520	1.23	5.76	0.77	3.12	4.34	11.91	212.65	77.53	4	12	4.026
6	35	122,000	8,420	16,840	4.27	8.32	2.35	4.45	9.42	16.18	98.03	57.06	9	16	4.038
7	24	96,000	8,420	16,800	4.27	8.30	2.35	4.44	9.42	16.15	98.03	57.17	9	16	4.070
8	19	1,000	12,660	11,560	6.31	5.78	3.41	3.13	12.83	11.94	72.00	77.33	13	12	4.095
9	20	1,000	17,940	11,560	8.85	5.78	4.73	3.13	17.07	11.94	54.11	77.33	17	12	4.096
10	30	163,600	12,710	6,240	6.33	3.22	3.42	1.80	12.87	7.67	71.77	120.42	13	8	4.096
11	29	34,200	17,990	4,240	8.87	2.26	4.74	1.30	17.11	6.06	53.98	152.34	17	6	4.139
12	31	169,000	12,500	6,240	6.23	3.22	3.37	1.80	12.70	7.67	72.73	120.42	13	8	4.148
13	32	140,000	17,980	4,240	8.87	2.26	4.74	1.30	17.10	6.06	54.00	152.34	17	6	4.192
14	5	147,000	24,260	11,520	11.89	5.76	6.31	3.12	22.14	11.91	41.70	77.53	22	12	4.229
15	6	97,000	18,940	11,520	9.33	5.76	4.98	3.12	17.87	11.91	51.67	77.53	18	12	4.268
16	12	244,000	18,990	22,080	9.35	10.84	4.99	5.76	17.91	20.39	51.56	45.28	18	20	4.293
17	11	53,000	16,300	27,360	8.06	13.38	4.32	7.08	15.75	24.63	58.63	37.45	16	24	4.357
18	3	47,800	18,990	27,400	9.35	13.40	4.99	7.09	17.91	24.67	51.56	37.44	18	24	4.371
19	4	444,000	29,540	37,960	14.43	18.48	7.63	9.73	26.38	33.15	35.00	27.86	26	33	4.383
															4.500
Total=		13,335,200													

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	1,460,537	4,584,195	0.9615	1,404,306	4,407,704
3	2,436,395	3,389,453	0.9246	2,252,691	3,133,888
4	3,877,382	4,961,922	0.8890	3,446,993	4,411,149
5	2,718,655	2,895,549	0.8548	2,323,907	2,475,115
TOTAL=	$10,492,970	$15,831,119		$9,427,897	$14,427,856

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D9, p.15)	
GVW(lb)=	114,653
Flywheel power (hp)=	460
Universal blade	
Loader (Caterpillar 988B, p.288)	
GVW(lb)=	85,560
Flywheel power (hp)=	375
Bucket size (cy)=	7
Motor Grader (Caterpillar 14G, p.79)	
GVW(lb)=	40,650
Flywheel power (hp)=	150
Standard 14' blade	

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	1,828	99	824,013	1-4.5	2,884,045	3.2	2,636,841
Loader	2	405	77	636,646	1-4.5	2,228,262	3.2	2,037,268
Grader	1	N.A.	45	187,533	1-4.5	656,365	3.2	600,105
Total=				$1,648,192		$5,768,672		$5,274,214

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 16 hour days 260 days per year

TABLE 4
WASTE TRANSPORTATION COSTS
FOR
SITES 1 AND 6

EXPENDITURE	SITE 1 COSTS 1987 ($)	SITE 1 PRESENT WORTH	SITE 6 COSTS 1987 ($)	SITE 6 PRESENT WORTH
HAUL COSTS (TABLE 2)	10,492,970	9,427,897	15,831,119	14,427,856
LOAD/UNLOAD (TABLE 3)-*	11,537,344	10,548,429	11,537,344	10,548,429
TOTAL=	$22,030,314	$19,976,326	$27,368,463	$24,976,284

* - A compensation factor has been added for level B worker protection.

COST ESTIMATE FOR 5-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
TWO HUNDRED FIFTY THOUSAND CUBIC YARD CELLS (636' X 636' X 43' HIGH)
BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-4	PRESENT WORTH CONST. COSTS YRS 0-4
Site Preparation								
Clearing Grubbing	690 acres	1000	690,200	0-4	172,550	3.630	469,767	642,317
Earthwork-cut	3,150,644 bcy	3	9,451,932	0-4	2,362,983	3.630	6,433,221	8,796,204
Earthwork-fill	3,636,878 bcy	3	10,910,634	0-4	2,727,659	3.630	7,426,050	10,153,709
Cell Berms	11,271,918 bcy	3	33,815,754	0-4	8,453,939	3.630	23,015,848	31,469,786
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8'x 12'x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	92,225 ft	50	4,611,250	0-4	0	3.630	4,184,709	4,184,709
Surface Water Control								
Ditch	117,200 ft	6	744,220	0-4	0	3.630	675,380	675,380
Detention Pond (280'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	26,894 lf	20	537,880	0	537,880	1.000	0	537,880
								0
Cell Construction(250,000 cy cell)	64 ea	1,673,490	107,103,360	0-3	26,775,840	2.775	74,302,956	101,078,796
SUB TOTAL=			$168,655,230		$41,820,850			$158,328,781
Engineering design, plans and spec's (10% of total costs)			16,865,523		16,865,523			16,865,523
Contingency fund (15% of total costs)			25,298,285		25,298,285			25,298,285
Total =			$210,819,038		$83,984,658			$200,492,589

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	3.5	22,030,314	-	19,976,326
Dust Suppression	80,000	-	80,000	3.5	280,000	2.852	228,160
Support Buildings And Equipment							
Administration	2,000	500	2,500	5	12,500	4.452	11,130
Personnel Decon/clean Trailers	5,000	500	5,500	5	27,500	4.452	24,486
Haul/Access Roads	-	20,000	20,000	5	100,000	4.452	89,040
Surface Water Control System	-	5,000	5,000	5	25,000	4.452	22,260
Sampling monitoring wells (quarterly)	5,000	-	5,000	5	25,000	4.452	22,260
Administration Personnel							
1-Site Manager	55,000	-	55,000	5	275,000	4.452	244,860
1-Cell construction foreman	45,000	-	45,000	4	180,000	3.630	163,350
1-Waste placement foreman	45,000	-	45,000	3.5	157,500	2.852	128,340
2-Facilities foreman	90,000	-	90,000	4	360,000	3.630	326,700
4-Laborers	120,000	-	120,000	5	600,000	4.452	534,240
6-QA/QC personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
6-Health & Safety personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
4-Field engineering support	140,000	-	140,000	3.5	490,000	2.852	399,280
2-Scale house technicians	50,000	-	50,000	3.5	175,000	2.852	142,600
4-Security	120,000	-	120,000	5	600,000	4.452	534,240
2-secretarys	40,000	-	40,000	5	200,000	4.452	178,080
TOTAL=					$26,881,814		$24,120,520

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	3.5	0.872	13,079
Decontaminate Haul Roads						
Longitudinal roads on site 1	47,243	3	141,729	3.5	0.872	123,588
Section roads	15,000	3	45,000	3.5	0.872	39,240
Surface Water Control						
Ditch (Decon)	139,468	1	69,734	3.5	0.872	60,808
Pond (Remove)	1	5,000	5,000	3.5	0.872	4,360
		TOTAL=	$276,463			$241,074

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	14.212	21,318
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	14.212	14,212
Monitoring Wells	5,000	-	5,000	30	150,000	14.212	71,060
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	14.212	355,300
Security Guard	15,000	-	15,000	30	450,000	14.212	213,180
TOTAL=					$1,425,000		$675,070

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
5 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	210,819,038	200,492,589
Operation & Main. (Table 2)	26,881,814	24,120,520
Closure (Table 3)	276,463	241,074
Post Closure (Table 4)	1,425,000	675,070
TOTAL=	$239,402,314	$225,529,253

* - Based on a 4% discount rate (Interest rate - Inflation rate)

5 YEAR BUILDOUT PERIOD - 9 CONCEPT DESIGN - ONE MILLION CUBIC YARD CELLS

COST ESTIMATE FOR 5-YEAR BUILDOUT ON PRIMARY SITE
9-CELL CONCEPT
ONE MILLION CUBIC YARD CELLS (1004' X 1004' X 43' HIGH)
ESTIMATE BASED ON THE DISPOSAL OF 15 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-4	PRESENT WORTH CONST. COSTS YRS 0-4
Site Preparation								
Clearing Grubbing	527 acres	1000	526,800	0-4	131,700	3.630	350,553	490,253
Earthwork-cut	3,721,164 bcy	3	11,163,492	0-4	2,790,873	3.630	7,598,152	10,389,025
Earthwork-fill	675,600 bcy	3	2,026,800	0-4	506,700	3.630	1,379,491	1,886,191
Cell Berms	3,952,800 bcy	3	11,858,400	0-4	2,964,600	3.630	8,071,124	11,035,724
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 sa	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	40,560 ft	50	2,028,000	0-4	0	3.630	1,840,410	1,840,410
Surface Water Control								
Ditch	68,640 ft	6	435,864	0-4	0	3.630	395,547	395,547
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	22,200 lf	20	444,000	0	444,000	1.000	0	444,000
								0
Cell Construction (1,000,000 cy cell)	16 ea	5,636,599	90,185,584	0-3	22,546,396	2.775	62,566,249	85,112,645
SUB TOTAL=			$119,458,940		$30,174,269			$112,383,794
Engineering design, plans and spec's (10% of total costs)			11,945,894		11,945,894			11,945,894
Contingency fund (15% of total costs)			17,918,841		17,918,841			17,918,841
Total =			$149,323,675		$60,039,004			$142,248,529

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	3.5	22,030,314	-	19,976,326
Dust Suppression	80,000	-	80,000	3.5	280,000	2.852	228,160
Support Buildings And Equipment							
Administration	2,000	500	2,500	5	12,500	4.452	11,130
Personnel Decon/clean Trailers	5,000	500	5,500	5	27,500	4.452	24,486
Haul/Access Roads	-	20,000	20,000	5	100,000	4.452	89,040
Surface Water Control System	-	5,000	5,000	5	25,000	4.452	22,260
Sampling monitoring wells (quarterly)	5,000	-	5,000	5	25,000	4.452	22,260
Administration Personnel							
1-Site Manager	55,000	-	55,000	5	275,000	4.452	244,860
1-Cell construction foreman	45,000	-	45,000	4	180,000	3.630	163,350
1-Waste placement foreman	45,000	-	45,000	3.5	157,500	2.852	128,340
2-Facilities foreman	90,000	-	90,000	4	360,000	3.630	326,700
4-Laborers	120,000	-	120,000	5	600,000	4.452	534,240
6-QA/QC personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
6-Health & Safety personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
4-Field engineering support	140,000	-	140,000	3.5	490,000	2.852	399,280
2-Scale house technicians	50,000	-	50,000	3.5	175,000	2.852	142,600
4-Security	120,000	-	120,000	5	600,000	4.452	534,240
2-secretarys	40,000	-	40,000	5	200,000	4.452	178,080
TOTAL=					$26,881,814		$24,120,520

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	3.5	0.872	13,079
Decontaminate Haul Roads						
Longitudinal roads on site 1	28,104	3	84,312	3.5	0.872	73,520
Section roads	15,000	3	45,000	3.5	0.872	39,240
Surface Water Control						
Ditch (Decon)	68,664	1	34,332	3.5	0.872	29,938
Pond (Remove)	1	5,000	5,000	3.5	0.872	4,360
		TOTAL=	$183,644			$160,136

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	14.212	21,318
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	14.212	14,212
Monitoring Wells	5,000	-	5,000	30	150,000	14.212	71,060
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	14.212	355,300
Security Guard	15,000	-	15,000	30	450,000	14.212	213,180
TOTAL=					$1,425,000		$675,070

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
5 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	149,323,675	142,240,329
Operation & Main. (Table 2)	26,901,814	24,120,320
Closure (Table 3)	183,644	160,135
Post Closure (Table 4)	1,405,000	675,070
TOTAL=	$177,814,133	$167,204,254

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 5-YEAR BUILDOUT ON PRIMARY SITE
D-CELL CONCEPT
ONE & ONE HALF MILLION CUBIC YARD CELLS (1004' X 1004' X 60' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-4	PRESENT WORTH CONST. COSTS YRS 0-4
Site Preparation								
Clearing Grubbing	378 acres	1000	378,000	0-4	94,500	3.630	257,276	351,776
Earthwork-cut	4,904,400 bcy	3	14,713,200	0-4	3,678,300	3.630	10,014,172	13,692,472
Earthwork-fill	154,200 bcy	3	462,600	0-4	115,650	3.630	314,857	430,507
Cell Berms	5,760,000 bcy	3	17,280,000	0-4	4,320,000	3.630	11,761,200	16,081,200
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	31,560 ft	50	1,578,000	0-4	0	3.630	1,432,035	1,432,035
Surface Water Control								
Ditch	40,300 ft	6	255,905	0-4	0	3.630	232,234	232,234
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	19,680 lf	20	393,600	0	393,600	1.000	0	393,600
								0
Cell Construction (1,500,000 cy cell)	10.67 ea	5,571,300	59,448,844	0-3	14,862,211	2.775	41,242,635	56,104,846
SUB TOTAL=			$95,300,149		$24,254,261			$89,508,670
Engineering design, plans and spec's (10% of total costs)			9,530,015		9,530,015			9,530,015
Contingency fund (15% of total costs)			14,295,022		14,295,022			14,295,022
Total =			$119,125,186		$48,079,298			$113,333,708

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	3.5	22,030,314	-	19,976,386
Dust Suppression	80,000	-	80,000	3.5	280,000	2.852	228,160
Support Buildings And Equipment							
Administration	2,000	500	2,500	5	12,500	4.452	11,130
Personnel Decon/clean Trailers	5,000	500	5,500	5	27,500	4.452	24,486
Haul/Access Roads	-	20,000	20,000	5	100,000	4.452	89,040
Surface Water Control System	-	5,000	5,000	5	25,000	4.452	22,260
Sampling monitoring wells (quarterly)	5,000	-	5,000	5	25,000	4.452	22,260
Administration Personnel							
1-Site Manager	55,000	-	55,000	5	275,000	4.452	244,860
1-Cell construction foreman	45,000	-	45,000	4	180,000	3.630	163,350
1-Waste placement foreman	45,000	-	45,000	3.5	157,500	2.852	128,340
2-Facilities foreman	90,000	-	90,000	4	360,000	3.630	326,700
4-Laborers	120,000	-	120,000	5	600,000	4.452	534,240
6-QA/QC personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
6-Health & Safety personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
4-Field engineering support	140,000	-	140,000	3.5	490,000	2.852	399,280
2-Scale house technicians	50,000	-	50,000	3.5	175,000	2.852	142,600
4-Security	120,000	-	120,000	5	600,000	4.452	534,240
2-secretarys	40,000	-	40,000	5	200,000	4.452	178,080
TOTAL=					$25,881,814		$24,120,320

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	3.5	0.872	13,079
Decontaminate Haul Roads						
Longitudinal roads on site 1	16,800	3	50,400	3.5	0.872	43,949
Suction roads	15,000	3	45,000	3.5	0.872	39,240
Surface Water Control						
Ditch (Decon)	48,350	1	24,180	3.5	0.872	21,085
Pond (Remove)	1	5,000	5,000	3.5	0.872	4,360
		TOTAL=	$139,580			$121,712

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEAR-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	14.212	21,318
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	14.212	14,212
Monitoring Wells	5,000	-	5,000	30	150,000	14.212	71,060
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	14.212	355,300
Security Guard	15,000	-	15,000	30	450,000	14.212	213,180
TOTAL=					$1,425,000		$675,070

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

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TABLE 5
COST SUMMARY
5 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	119,125,186	113,333,708
Operation & Main. (Table 2)	26,881,814	24,120,520
Closure (Table 3)	139,380	121,712
Post Closure (Table 4)	1,425,000	675,070
TOTAL=	$147,571,380	$138,251,009

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 5-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
THREE MILLION CUBIC YARD CELLS (1639' x 1639' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-4	PRESENT WORTH CONST. COSTS YRS 0-4
Site Preparation								
Clearing Grubbing	497 acres	1000	496,800	0-4	124,200	3.630	338,135	462,335
Earthwork-cut	4,425,240 bcy	3	13,275,720	0-4	3,318,930	3.630	9,035,787	12,354,717
Earthwork-fill	1,312,440 bcy	3	3,937,320	0-4	984,330	3.630	2,679,838	3,664,168
Cell Berms	3,704,520 bcy	3	11,113,560	0-4	2,778,390	3.630	7,564,167	10,342,557
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	27,840 ft	50	1,392,000	0-4	0	3.630	1,263,240	1,263,240
Surface Water Control								
Ditch	41,760 ft	6	265,176	0-4	0	3.630	240,647	240,647
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	21,360 lf	20	427,200	0	427,200	1.000	0	427,200
								0
Cell Construction (3,000,000 cy cell)	5 ea	15,698,305	78,491,525	0-3	19,622,881	2.775	54,453,495	74,076,377
(1,000,000 cy cell)	1 ea	5,636,599	5,636,599	3.5	0	0.872	4,914,551	4,914,551
SUB TOTAL=			$115,825,980		$28,045,931			$108,535,791
Engineering design, plans and spec's (10% of total costs)			11,582,590		11,582,590			11,582,590
Contingency fund (15% of total costs)			17,373,885		17,373,885			17,373,885
Total =			$144,782,375		$57,002,406			$137,492,266

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-+ OF O&M	TOTAL COST	PRESENT -++ WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	3.5	22,030,314	-	19,976,326
Dust Suppression	80,000	-	80,000	3.5	280,000	2.852	228,160
Support Buildings And Equipment							
Administration	2,000	500	2,500	5	12,500	4.452	11,130
Personnel Decon/clean Trailers	5,000	500	5,500	5	27,500	4.452	24,486
Haul/Access Roads	-	20,000	20,000	5	100,000	4.452	89,040
Surface Water Control System	-	5,000	5,000	5	25,000	4.452	22,260
Sampling monitoring wells (quarterly)	5,000	-	5,000	5	25,000	4.452	22,260
Administration Personnel							
1-Site Manager	55,000	-	55,000	5	275,000	4.452	244,860
1-Cell construction foreman	45,000	-	45,000	4	180,000	3.630	163,350
1-Waste placement foreman	45,000	-	45,000	3.5	157,500	2.852	128,340
2-Facilities foreman	90,000	-	90,000	4	360,000	3.630	326,700
4-Laborers	120,000	-	120,000	5	600,000	4.452	534,240
6-QA/QC personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
6-Health & Safety personnel	192,000	-	192,000	3.5	672,000	2.852	547,584
4-Field engineering support	140,000	-	140,000	3.5	490,000	2.852	399,280
2-Scale house technicians	50,000	-	50,000	3.5	175,000	2.852	142,600
4-Security	120,000	-	120,000	5	600,000	4.452	534,240
2-secretarys	40,000	-	40,000	5	200,000	4.452	178,080
TOTAL=					$26,081,814		$24,120,520

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	3.5	0.872	13,079
Decontaminate Haul Roads						
Longitudinal roads on site 1	13,920	3	41,760	3.5	0.872	36,415
Section roads	15,000	3	45,000	3.5	0.872	39,240
Surface Water Control						
Ditch (Decon)	34,800	1	17,400	3.5	0.872	15,173
Pond (Remove)	1	5,000	5,000	3.5	0.872	4,360
		TOTAL=	$124,160			$108,266

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	14.212	21,318
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	14.212	14,212
Monitoring Wells	5,000	-	5,000	30	150,000	14.212	71,060
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	14.212	355,300
Security Guard	15,000	-	15,000	30	450,000	14.212	213,180
TOTAL=					$1,425,000		$675,070

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
5 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	144,782,375	137,492,266
Operation & Main. (Table 2)	26,881,814	24,120,520
Closure (Table 3)	124,160	108,266
Post Closure (Table 4)	1,425,000	675,070
TOTAL=	$173,213,349	$162,396,122

* - Based on a 4% discount rate (Interest rate - Inflation rate)

Rocky Mountain Arsenal - UBRT 5650.704 TASK 27
Ebasco Services Inc.
Estimate of Waste Transportation Costs for a 10 Year Buildout Period

Notes:

Waste transportation costs are estimated in two parts: Haul costs (Table 2) and Loading/unloading costs (Table 3).
Waste Transportation Costs to sites 1 and 6 (Summation of tables 2 and 3) are presented in Table 4.
The first and last years of the buildout period are used for facility construction and closure,respectively.
Loading/unloading costs are uniform throughout the buildout period.
Equipment production rates are based on 50 minute hours (83% efficiency).
Equipment production rates were estimated from the 12ed. of the Caterpillar Performance Handbook.
Equipment costs are based on an hourly rental fee that includes overhead for a driver,a mechanic, fuel, maintenance and spare parts.
Rental costs include a discount for both a volume fleet and long term rental agreement.
Equipment rental costs were provided by EBASCO Constructors Inc.

HAUL COSTS

Haul costs are considered to be costs associated with the transportation of waste from the contamination site to the land disposal facility.
Haul costs are calculated individually for sections.
Waste volumes in sections were taken from the DRLF or the Phase I Contamination Assessment Reports if available.
Table 1 provides an estimate of the fleet size and time required to transport waste from sections to disposal sites 1 & 6.
Haul distances were measured from the center of "sections" to the centroid of the disposal site via the existing road grids.
Haul costs depend on haul distances and thus vary over the buildout period.
Waste material is transported in end dump haul trucks (off-road size).
A summary of haul costs by sections are presented in table 1 for both sites 1 and 6..
The annual "haul costs" for transportation of waste material is presented in table 2.

Equipment Specifications

End dump haul truck (Caterpillar 769C, p.285)

Empty vehicle weight (EVW)= 68,000lb	
Gross vehicle weight (GVW)=138,000lb	
Payload	= 70,000lb or 35 tons
Capacity	= 22.8 cy (struck)

Estimation of haul truck production rates

Haul truck production rates are a function of the travel time to and from the contamination site and land disposal facility.
The total round trip travel time is the sum of the haul time, return time and load/unload time.
The haul times and return times can be estimated by equations 1 and 2 derived from the Caterpillar Handbook (p.233-234).
The load/unload time is an assumed constant.

Eq. (1) Haul time (min)= 0.82 + 4.81E-4(X) were X is in feet, based on the GVW and a total resistance of 4% (2% rolling + 2% grade)

Eq. (2) Return time (min)= 0.24 + 2.30E-4(X) were X is in feet, based on the EVW and 0% total resistance (2% rolling and -2% grade)

Input parameters for calculation of Table 1 and 2.

Waste placement years=	8	(5 days/week-52 weeks/year)
Construction days per year=	260	
Begin waste placement at end of year	1	
Load/unload time (minutes)=	2.15	
Hourly 769C rental fee ($)=	68.79	
Annual waste placement rate (BCY)=	1,666,900	

TABLE 1
Required fleet size for Transportation of waste
to sites 1 and 6

CLEAN UP PRIORITY	SECTION NO.	WASTE VOLUME (BCY)	HAUL DISTANCE SITE 1B	HAUL DISTANCE SITE 6	HAUL TIME (MIN) SITE 1B	HAUL TIME (MIN) SITE 6	RETURN TIME (MIN) SITE 1B	RETURN TIME (MIN) SITE 6	TOTAL TRAVEL TIME SITE 1B	TOTAL TRAVEL TIME SITE 6	PRODUCTION RATE (BCY/HR) SITE 1	PRODUCTION RATE (BCY/HR) SITE 6	REQUIRED FLEET SIZE SITE 1	REQUIRED FLEET SIZE SITE 6	YEAR OF CLEAN UP SITE 1 OR 6
															1
1	28	3,996,000	3,100	16,000	1.71	8.30	1.02	4.44	5.15	16.15	179.45	57.17	4	14	3.397
2	36	3,630,700	7,300	11,560	3.77	5.78	2.09	3.13	8.58	11.94	107.57	77.33	7	10	5.573
3	1	2,105,000	13,700	15,040	6.81	7.84	3.67	4.20	13.66	15.38	67.60	60.04	12	13	6.887
4	2	1,715,500	13,700	22,120	6.81	10.06	3.67	5.77	13.66	20.42	67.60	45.21	12	18	7.906
5	25	47,300	2,100	11,520	1.23	5.76	0.77	3.12	4.34	11.91	212.68	77.53	4	10	7.944
6	35	122,000	8,420	16,040	4.27	8.32	2.35	4.45	9.42	16.18	98.03	57.06	8	14	8.048
7	24	56,000	8,420	16,000	4.27	8.30	2.35	4.44	9.42	16.15	98.03	57.17	8	14	8.073
8	19	1,000	12,660	11,560	6.31	5.78	3.41	3.13	12.83	11.94	72.00	77.33	11	10	8.076
9	20	1,000	17,940	11,560	8.85	5.78	4.73	3.13	17.07	11.94	54.11	77.33	15	10	8.076
10	30	163,600	12,710	6,240	6.33	3.22	3.42	1.80	12.87	7.67	71.77	180.42	11	7	8.175
11	29	34,200	17,990	4,240	8.87	2.26	4.74	1.30	17.11	6.06	53.98	152.34	15	5	8.195
12	31	169,000	12,500	6,240	6.23	3.22	3.37	1.80	12.70	7.67	72.73	180.42	11	7	8.296
13	32	140,000	17,980	4,240	8.87	2.26	4.74	1.30	17.10	6.06	54.00	152.34	15	5	8.380
14	5	147,000	24,260	11,520	11.89	5.76	6.31	3.12	22.14	11.91	41.70	77.53	19	10	8.469
15	6	97,000	18,940	11,520	9.33	5.76	4.98	3.12	17.87	11.91	51.67	77.53	16	10	8.527
16	12	244,000	18,990	22,000	9.35	10.04	4.99	5.76	17.91	20.39	51.56	45.28	16	18	8.672
17	11	53,000	16,300	27,360	8.06	13.38	4.32	7.08	15.75	24.63	58.63	37.49	14	21	8.705
18	3	47,000	18,990	27,400	9.35	13.40	4.99	7.09	17.91	24.67	51.56	37.44	16	21	8.734
19	4	444,000	29,540	37,960	14.43	18.48	7.63	9.73	26.38	33.15	35.00	27.86	23	29	9.000
Total=		13,335,200													

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	638,985	2,005,585	0.9615	614,384	1,928,370
3	638,985	2,005,585	0.9246	590,806	1,854,364
4	923,610	1,657,119	0.8890	821,090	1,473,179
5	1,065,923	1,482,886	0.8548	911,151	1,267,571
6	1,328,603	1,660,776	0.8219	1,091,979	1,364,992
7	1,696,355	2,014,231	0.7903	1,340,629	1,591,846
8	1,652,464	2,492,374	0.7599	1,255,707	1,893,955
9	2,328,116	2,341,417	0.7307	1,701,155	1,710,873
10	0	0	0.7026	0	0
TOTAL=	$10,273,041	$15,659,973		$8,326,900	$13,085,151

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D9, p.15)
GVW(lb)= 114,653
Flywheel power (hp)= 460
Universal blade

Loader (Caterpillar 988B, p.20C
GVW(lb)= 85,560
Flywheel power (hp)= 375
Bucket size (cy)= 7

Motor Grader (Caterpillar 14G, p.79)
GVW(lb)= 40,650
Flywheel power (hp)= 150
Standard 14' blade

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	1,808	99	412,006	1-8	3,296,051	6.733	2,774,039
Loader	2	405	77	318,323	1-8	2,546,586	6.733	2,143,270
Grader	1	N.A.	45	93,766	1-8	750,131	6.733	631,329
Total=				$824,095		$6,592,768		$5,548,638

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 8 hour days 260 days per year

TABLE 4
WASTE TRANSPORTATION COSTS
FOR
SITES 1 AND 6

EXPENDITURE	SITE 1 COSTS 1987 ($)	SITE 1 PRESENT WORTH	SITE 6 COSTS 1987 ($)	SITE 6 PRESENT WORTH
HAUL COSTS (TABLE 2)	10,273,041	8,326,900	15,659,973	13,085,151
LOAD/UNLOAD (TABLE 3)-*	7,911,322	6,658,366	7,911,322	6,658,366
TOTAL=	$18,184,362	$14,985,266	$23,571,295	$19,743,517

* - A COMPENSATION FACTOR HAS BEEN ADDED FOR LEVEL B WORKER PROTECTION

COST ESTIMATE FOR 10-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
250 THOUSAND CUBIC YARD CELLS (636' x 636' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-7	PRESENT WORTH CONST. COSTS YRS 0-7
Site Preparation								
Clearing Grubbing	696 acres	1000	696,000	0-6	153,120	5.242	474,296	627,416
Earthwork-cut	3,177,120 bcy	3	9,531,360	0-6	2,096,899	5.242	6,495,241	8,592,140
Earthwork-fill	3,667,440 bcy	3	11,002,320	0-6	2,420,510	5.242	7,497,641	9,918,151
Cell Berms	11,366,640 bcy	3	34,099,920	0-6	7,501,982	5.242	23,237,731	30,739,714
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	93,000 ft	50	4,650,000	0-6	0	5.242	4,062,500	4,062,500
Surface Water Control								
Ditch	117,200 ft	6	744,820	0-6	0	5.242	650,200	650,200
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	27,120 lf	20	542,400	0	542,400	1.000	0	542,400
								0
Cell Construction (250,000 cy cell)	64 ea	1,673,490	107,103,360	0-5	9,099,023	4.452	87,263,062	96,362,085
			0	6	0	0.790	0	0
SUB TOTAL=			$169,159,580		$22,603,935			$152,284,656
Engineering design, plans and spec's (10% of total costs)			16,915,958		16,915,958			16,915,958
Contingency fund (15% of total costs)			25,373,937		25,373,937			25,373,937
Total =			$211,449,475		$64,893,830			$194,574,551

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	8	23,458,577	-	19,424,176
Dust Suppression	80,000	-	80,000	8	640,000	6.733	538,640
Support Buildings And Equipment							
Administration	2,000	500	2,500	10	25,000	8.111	20,278
Personnel Decon/clean Trailers	5,000	500	5,500	10	55,000	8.111	44,611
Haul/Access Roads	-	20,000	20,000	10	200,000	8.111	162,220
Surface Water Control System	-	5,000	5,000	10	50,000	8.111	40,555
Sampling monitoring wells (quarterly)	5,000	-	5,000	10	50,000	8.111	40,555
Administration Personnel							
1-Site Manager	55,000	-	55,000	10	550,000	8.111	446,105
1-Cell construction foreman	45,000	-	45,000	9	405,000	7.435	334,575
1-Waste placement foreman	45,000	-	45,000	8	360,000	6.733	302,985
1-Facilities foreman	45,000	-	45,000	9	405,000	7.435	334,575
2-Laborers	60,000	-	60,000	10	600,000	8.111	486,660
3-QA/QC personnel	96,000	-	96,000	8	768,000	6.733	646,368
3-Health & Safety personnel	96,000	-	96,000	8	768,000	6.733	646,368
2-Field engineering support	70,000	-	70,000	8	560,000	6.733	471,310
1-Scale house technician	25,000	-	25,000	8	200,000	6.733	168,325
2-Security	60,000	-	60,000	10	600,000	8.111	486,660
1-secretary	20,000	-	20,000	10	200,000	8.111	162,220
TOTAL=					$29,894,577		$24,757,186

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 5
COST SUMMARY
10 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	211,449,475	194,574,551
Operation & Main. (Table 2)	29,894,577	24,757,185
Closure (Table 3)	278,240	203,310
Post Closure (Table 4)	1,425,000	526,443
TOTAL=	$243,047,292	$220,061,489

*Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 10-YEAR BUILDOUT ON PRIMARY SITE
9-CELL CONCEPT
ONE MILLION CUBIC YARD CELLS (1004 x 1004 x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-7	PRESENT WORTH CONST. COSTS YRS 0-7
Site Preparation								
Clearing Grubbing	527 acres	1000	527,000	0-6	115,896	5.242	358,958	474,009
Earthwork-cut	3,721,164 bcy	3	11,163,492	0-6	2,455,560	5.242	7,607,473	10,063,441
Earthwork-fill	675,600 bcy	3	2,026,800	0-6	445,896	5.242	1,381,183	1,827,079
Cell Berms	3,952,920 bcy	3	11,858,760	0-6	2,608,927	5.242	8,081,271	10,690,198
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8'x 12'x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	40,560 ft	50	2,028,000	0-6	0	5.242	1,771,756	1,771,756
Surface Water Control								
Ditch	57,200 ft	6	343,200	0-6	0	5.242	317,333	317,333
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	22,200 lf	20	444,000	0	444,000	1.000	0	444,000
								0
Cell Construction (1,000,000 cy cell)	16 ea	5,636,599	90,185,584	0-5	9,093,023	4.452	72,159,474	81,258,497
SUB TOTAL=			$119,386,636		$15,959,710			$107,677,234
Engineering design, plans and spec's (10% of total costs)			11,938,666		11,938,666			11,938,666
Contingency fund (15% of total costs)			17,907,998		17,907,998			17,907,998
Total =			$149,233,300		$45,806,374			$137,523,898

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,502
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* -Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	8	23,438,577	-	19,424,176
Dust Suppression	80,000	-	80,000	8	640,000	6.733	538,640
Support Buildings And Equipment							
Administration	2,000	500	2,500	10	25,000	8.111	20,278
Personnel Decon/clean Trailers	5,000	500	5,500	10	55,000	8.111	44,611
Haul/Access Roads	-	20,000	20,000	10	200,000	8.111	162,220
Surface Water Control System	-	5,000	5,000	10	50,000	8.111	40,555
Sampling monitoring wells (quarterly)	5,000	-	5,000	10	50,000	8.111	40,555
Administration Personnel							
1-Site Manager	55,000	-	55,000	10	550,000	8.111	446,105
1-Cell construction foreman	45,000	-	45,000	9	405,000	7.435	334,575
1-Waste placement foreman	45,000	-	45,000	8	360,000	6.733	302,985
1-Facilities foreman	45,000	-	45,000	9	405,000	7.435	334,575
2-Laborers	60,000	-	60,000	10	600,000	8.111	486,660
3-QA/QC personnel	96,000	-	96,000	8	768,000	6.733	646,368
3-Health & Safety personnel	96,000	-	96,000	8	768,000	6.733	646,368
2-Field engineering support	70,000	-	70,000	8	560,000	6.733	471,310
1-Scale house technician	25,000	-	25,000	8	200,000	6.733	168,325
2-Security	60,000	-	60,000	10	600,000	8.111	486,660
1-secretary	20,000	-	20,000	10	200,000	8.111	162,220
TOTAL=					$29,894,577		$24,757,183

* - Cost occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	8	0.731	10,961
Decontaminate Haul Roads						
Longitudinal roads on site 1	28,104	3	84,312	8	0.731	61,607
Section roads	15,000	3	45,000	8	0.731	32,882
Surface Water Control						
Ditch (Decon)	68,664	1	34,332	8	0.731	25,086
Pond (Remove)	1	5,000	5,000	8	0.731	3,654
		TOTAL=	$183,644			$134,189

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	11.083	16,625
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	11.083	11,083
Monitoring Wells	5,000	-	5,000	30	150,000	11.083	55,415
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	11.083	277,075
Security Guard	15,000	-	15,000	30	450,000	11.083	166,245
TOTAL=					$1,425,000		$526,443

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	8	0.731	10,961
Decontaminate Haul Roads						
Longitudinal roads on site 1	47,640	3	142,920	8	0.731	104,432
Section roads	15,000	3	45,000	8	0.731	32,882
Surface Water Control						
Ditch (Decon)	140,640	1	70,320	8	0.731	51,383
Pond (Remove)	1	5,000	5,000	8	0.731	3,654
		TOTAL=	$278,240			$203,310

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	11.083	16,625
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	11.083	11,083
Monitoring Wells	5,000	-	5,000	30	150,000	11.083	55,415
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	11.083	277,075
Security Guard	15,000	-	15,000	30	450,000	11.083	166,245
TOTAL=					$1,425,000		$526,443

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
10 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	149,233,320	137,523,898
Operation & Main. (Table 2)	29,894,577	24,757,185
Closure (Table 3)	183,644	134,189
Post Closure (Table 4)	1,425,000	526,443
TOTAL=	$180,736,541	$162,941,714

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 10-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
ONE & ONE HALF MILLION CUBIC YARD CELLS (100A x 100A x 60' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-7	PRESENT WORTH CONST. COSTS YRS 0-7
Site Preparation								
Clearing Grubbing	378 acres	1000	378,000	0-6	83,160	5.242	257,592	340,752
Earthwork-cut	4,904,400 bcy	3	14,713,200	0-6	3,236,904	5.242	10,026,457	13,263,361
Earthwork-fill	154,200 bcy	3	462,600	0-6	101,772	5.242	315,243	417,015
Cell Berms	5,760,000 bcy	3	17,280,000	0-6	3,801,600	5.242	11,775,629	15,577,229
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	31,560 ft	50	1,578,000	0-6	0	5.242	1,378,646	1,378,646
Surface Water Control								
Ditch	48,360 ft	6	307,086	0-6	0	5.242	268,291	268,291
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	19,680 lf	20	393,600	0	393,600	1.000	0	393,600 0
Cell Construction (1,500,000 cy cell)	10.67 ea	5,571,508	59,448,844	0-5	9,099,023	4.452	44,831,481	53,930,504
SUB TOTAL=			$95,351,330		$17,506,059			$86,359,398
Engineering design, plans and spec's (10% of total costs)			9,535,133		9,535,133			9,535,133
Contingency fund (15% of total costs)			14,302,699		14,302,699			14,302,699
Total =			$119,189,162		$41,343,891			$110,197,230

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	8	23,458,577	-	19,424,176
Dust Suppression	80,000	-	80,000	8	640,000	6.733	538,640
Support Buildings And Equipment							
Administration	2,000	500	2,500	10	25,000	8.111	20,278
Personnel Decon/clean Trailers	5,000	500	5,500	10	55,000	8.111	44,611
Haul/Access Roads	-	20,000	20,000	10	200,000	8.111	162,220
Surface Water Control System	-	5,000	5,000	10	50,000	8.111	40,555
Sampling monitoring wells (quarterly)	5,000	-	5,000	10	50,000	8.111	40,555
Administration Personnel							
1-Site Manager	55,000	-	55,000	10	550,000	8.111	446,105
1-Cell construction foreman	45,000	-	45,000	9	405,000	7.435	334,575
1-Waste placement foreman	45,000	-	45,000	8	360,000	6.733	302,985
1-Facilities foreman	45,000	-	45,000	9	405,000	7.435	334,575
2-Laborers	60,000	-	60,000	10	600,000	8.111	486,660
3-QA/QC personnel	96,000	-	96,000	8	768,000	6.733	646,368
3-Health & Safety personnel	96,000	-	96,000	8	768,000	6.733	646,368
2-Field engineering support	70,000	-	70,000	8	560,000	6.733	471,310
1-Scale house technician	25,000	-	25,000	8	200,000	6.733	168,325
2-Security	60,000	-	60,000	10	600,000	8.111	486,660
1-secretary	20,000	-	20,000	10	200,000	8.111	162,220
TOTAL=					$29,894,577		$24,757,185

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	8	0.731	10,961
Decontaminate Haul Roads						
Longitudinal roads on site 1	16,800	3	50,400	8	0.731	36,827
Section roads	15,000	3	45,000	8	0.731	32,882
Surface Water Control						
Ditch (Decon)	40,300	1	20,150	8	0.731	14,724
Pond (Remove)	1	5,000	5,000	8	0.731	3,654
		TOTAL=	$135,550			$99,046

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	11.083	16,625
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	11.083	11,083
Monitoring Wells	5,000	-	5,000	30	150,000	11.083	55,415
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	11.083	277,075
Security Guard	15,000	-	15,000	30	450,000	11.083	166,245
TOTAL=					$1,425,000		$526,443

* - Cost occurs at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
10 YEAR BUILDOUT
SITE I

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	119,189,162	110,197,230
Operation & Main. (Table 2)	29,894,577	24,757,185
Closure (Table 3)	135,550	99,046
Post Closure (Table 4)	1,425,000	526,443
TOTAL=	$150,644,289	$135,579,904

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 10-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
THREE MILLION CUBIC YARD CELLS (1639' x 1639' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-7	PRESENT WORTH CONST. COSTS YRS 0-7
Site Preparation								
Clearing Grubbing	497 acres	1000	496,800	0-6	109,296	5.242	338,549	447,845
Earthwork-cut	4,425,240 bcy	3	13,275,720	0-6	2,920,658	5.242	9,046,872	11,967,531
Earthwork-fill	1,312,440 bcy	3	3,937,320	0-6	866,210	5.242	2,683,126	3,549,336
Cell Berms	3,704,520 bcy	3	11,113,560	0-6	2,444,983	5.242	7,573,447	10,018,430
Support Buildings and Equipment								
Administration Building (40' x 60')	2,400 sq. ft	50	120,000	0	120,000	1.000	0	120,000
Personnel Decon. Trailer (8'x 12'x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 250')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	27,840 ft	50	1,392,000	0-6	0	5.242	1,216,144	1,216,144
Surface Water Control								
Ditch	41,760 ft	6	265,176	0-6	0	5.242	231,675	231,675
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	21,360 lf	20	427,200	0	427,200	1.000	0	427,[illegible] 0
Cell Construction (3,000,000 cy cell)	5 ea	15,698,305	78,491,525	0-5	9,099,023	4.452	61,787,084	70,886,107
(1,000,000 cy cell)	1 ea	5,636,599	5,636,599	6	0	0.790	4,454,604	4,454,604
SUB TOTAL=			$115,825,900		$16,657,371			$103,988,873
Engineering design, plans and spec's (10% of total costs)			11,582,590		11,582,590			11,582,590
Contingency fund (15% of total costs)			17,373,885		17,373,885			17,373,885
Total =			$144,782,375		$45,613,846			$132,945,348

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	8	23,458,577	-	19,424,176
Dust Suppression	80,000	-	80,000	8	640,000	6.733	538,640
Support Buildings And Equipment							
Administration	2,000	500	2,500	10	25,000	8.111	20,278
Personnel Decon/clean Trailers	5,000	500	5,500	10	55,000	8.111	44,611
Haul/Access Roads	-	20,000	20,000	10	200,000	8.111	162,220
Surface Water Control System	-	5,000	5,000	10	50,000	8.111	40,555
Sampling monitoring wells (quarterly)	5,000	-	5,000	10	50,000	8.111	40,555
Administration Personnel							
1-Site Manager	55,000	-	55,000	10	550,000	8.111	446,105
1-Cell construction foreman	45,000	-	45,000	9	405,000	7.435	334,575
1-Waste placement foreman	45,000	-	45,000	8	360,000	6.733	302,985
1-Facilities foreman	45,000	-	45,000	9	405,000	7.435	334,575
2-Laborers	60,000	-	60,000	10	600,000	8.111	486,660
3-QA/QC personnel	96,000	-	96,000	8	768,000	6.733	646,368
3-Health & Safety personnel	96,000	-	96,000	8	768,000	6.733	646,368
2-Field engineering support	70,000	-	70,000	8	560,000	6.733	471,310
1-Scale house technician	25,000	-	25,000	8	200,000	6.733	168,325
2-Security	60,000	-	60,000	10	600,000	8.111	486,660
1-secretary	20,000	-	20,000	10	200,000	8.111	162,220
TOTAL=					$29,894,577		$24,757,185

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	8	0.731	10,961
Decontaminate Haul Roads						
Longitudinal roads on site 1	13,920	3	41,760	8	0.731	30,514
Section roads	15,000	3	45,000	8	0.731	32,882
Surface Water Control						
Ditch (Decon)	41,760	1	20,880	8	0.731	15,257
Pond (Remove)	1	5,000	5,000	8	0.731	3,654
		TOTAL=	$127,640			$93,267

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	11.083	16,625
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	11.083	11,083
Monitoring Wells	5,000	-	5,000	30	150,000	11.083	55,415
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	11.083	277,075
Security Guard	15,000	-	15,000	30	450,000	11.083	166,245
TOTAL=					$1,425,000		$526,443

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
10 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	144,782,375	132,945,348
Operation & Main. (Table 2)	29,894,577	24,757,185
Closure (Table 3)	127,640	93,267
Post Closure (Table 4)	1,425,000	526,443
TOTAL=	$176,229,592	$158,322,242

* - Based on a 4% discount rate (Interest rate - Inflation rate)

Rocky Mountain Arsenal - UAST 5658.784 TASK 27
Ebasco Services Inc.
Estimate of Waste Transportation Costs for a 20 Year Buildout Period

Notes:

Waste transportation costs are estimated in two parts: Haul costs (Table 2) and Loading/unloading costs (Table 3).
Waste Transportation Costs to sites 1 and 6 (Summation of tables 2 and 3) are presented in Table 4.
The first and last years of the buildout period are used for facility construction and closure,respectively.
Loading/unloading costs are uniform throughout the buildout period.
Equipment production rates are based on 50 minute hours (83% efficiency).
Equipment production rates were estimated from the 12ed. of the Caterpillar Performance Handbook.
Equipment costs are based on an hourly rental fee that includes overhead for a driver,a mechanic, fuel, maintenance and spare parts.
Rental costs include a discount for both a volume fleet and long term rental agreement.
Equipment rental costs were provided by EBASCO Constructors Inc.

HAUL COSTS

Haul costs are considered to be costs associated with the transportation of waste from the contamination site to the land disposal facility.
Haul costs are calculated individually for sections.
Waste volumes in sections were taken from the DALF or the Phase 1 Contamination Accessment Reports if available.
Table 1 provides an estimate of the fleet size and time required to transport waste from sections to disposal sites 1 & 6.
Haul distances were measured from the center of "sections" to the centroid of the disposal site via the existing road grids.
Haul costs depend on haul distances and thus vary over the buildout period.
Waste material is transported in end dump haul trucks (off-road size).
A summary of haul costs by sections are presented in table 1 for both sites 1 and 6..
The annual "haul costs" for transportation of waste material is presented in table 2.

Equipment Specifications

End dump haul truck (Caterpillar 769C, p.226)

Empty vehicle weight (EVW)= 68,000lb
Gross vehicle weight (GVW)=138,000lb
Payload = 70,000lb or 35 tons
Capacity = 22.8 cy (struck)

Estimation of haul truck production rates

Haul truck production rates are a function of the travel time to and from the contamination site and land disposal facility.
The total round trip travel time is the sum of the haul time, return time and load/unload time.
The haul times and return times can be estimated by equations 1 and 2 derived from the Caterpillar Handbook (p.233-234).
The load/unload time is an assumed constant.

Eq. (1) Haul time (min)= 0.22 + 4.81E-4(X) were X is in feet, based on the GVW and a total resistance of 4% (2% rolling + 2% grade)

Eq. (2) Return time (min)= 0.24 + 2.50E-4(X) were X is in feet, based on the EVW and 0% total resistance (2% rolling and -2% grade)

Input parameters for calculation of Table 1 and 2.

Waste placement years=	18
Construction days per year=	260 (5 days/week-52 weeks/year)
Begin waste placement at end of year	1
Load/unload time (minutes)=	2.15
Hourly 769C rental fee ($)=	68.79
Annual waste placement rate (BCY)=	740,844

TABLE 1
Required fleet size for Transportation of waste
to sites 1 and 6

CLEAN UP PRIORITY	SECTION NO.	WASTE VOLUME (BCY)	HAUL DISTANCE SITE 1B	HAUL DISTANCE SITE 6	HAUL TIME (MIN) SITE 1B	HAUL TIME (MIN) SITE 6	RETURN TIME (MIN) SITE 1B	RETURN TIME (MIN) SITE 6	TOTAL TRAVEL TIME SITE 1B	TOTAL TRAVEL TIME SITE 6	PRODUCTION RATE(BCY/HR) SITE 1	PRODUCTION RATE(BCY/HR) SITE 6	REQUIRED FLEET SIZE SITE 1	REQUIRED FLEET SIZE SITE 6	YEAR OF CLEAN UP SITE 1 OR 6
1	26	3,996,000	3,100	16,800	1.71	8.30	1.02	4.44	5.15	16.15	179.45	57.17	2	6	1
2	36	3,630,700	7,380	11,560	3.77	5.78	2.09	3.13	8.58	11.94	107.57	77.33	3	5	6.394
3	1	2,185,800	13,700	15,840	6.81	7.84	3.67	4.20	13.66	15.38	67.60	60.04	5	6	11.295
4	2	1,715,800	13,700	22,120	6.81	10.86	3.67	5.77	13.66	20.42	67.60	45.21	5	8	14.245
5	25	47,300	2,100	11,520	1.23	5.76	0.77	3.12	4.34	11.91	212.65	77.53	2	5	16.561
6	35	122,000	8,420	16,840	4.27	8.32	2.35	4.45	9.42	16.18	98.03	57.06	4	6	16.625
7	24	96,000	8,420	16,800	4.27	8.30	2.35	4.44	9.42	16.15	98.03	57.17	4	6	16.790
8	19	1,000	12,660	11,560	6.31	5.78	3.41	3.13	12.83	11.94	72.00	77.33	5	5	16.919
9	20	1,000	17,940	11,560	8.85	5.78	4.73	3.13	17.07	11.94	54.11	77.33	7	5	16.920
10	30	163,600	12,710	6,240	6.33	3.22	3.42	1.80	12.87	7.67	71.77	120.42	5	3	16.922
11	29	34,200	17,990	4,240	8.87	2.26	4.74	1.30	17.11	6.06	53.98	152.34	7	2	17.143
12	31	169,000	12,500	6,240	6.23	3.22	3.37	1.80	12.70	7.67	72.73	120.42	5	3	17.189
13	32	140,000	17,980	4,240	8.87	2.26	4.74	1.30	17.10	6.06	54.00	152.34	7	2	17.417
14	5	147,000	24,260	11,520	11.89	5.76	6.31	3.12	22.14	11.91	41.70	77.53	9	5	17.606
15	6	97,000	18,940	11,520	9.33	5.76	4.98	3.12	17.87	11.91	51.67	77.53	7	5	17.804
16	12	244,000	18,990	22,080	9.35	10.84	4.99	5.76	17.91	20.39	51.56	45.28	7	8	17.935
17	11	53,000	16,300	27,360	8.06	13.38	4.32	7.08	15.75	24.63	58.63	37.49	6	10	18.265
18	3	47,800	18,990	27,400	9.35	13.40	4.99	7.09	17.91	24.67	51.56	37.44	7	10	18.336
19	4	444,000	29,540	37,960	14.43	18.48	7.63	9.73	26.38	33.15	35.00	27.86	10	13	18.401
															19.000
	Total=	13,335,200													

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	283,993	891,371	0.9615	273,071	857,088
3	283,993	891,371	0.9246	262,568	824,123
4	283,993	891,371	0.8890	252,469	792,426
5	283,993	891,371	0.8548	242,759	761,948
6	283,993	891,371	0.8219	233,422	732,642
7	410,493	736,497	0.7903	324,419	582,065
8	473,744	659,060	0.7599	360,006	500,832
9	473,744	659,060	0.7307	346,160	481,569
10	473,744	659,060	0.7026	332,846	463,047
11	473,744	659,060	0.6756	320,044	445,238
12	660,538	785,560	0.6496	429,073	510,285
13	753,935	848,810	0.6246	470,986	530,165
14	753,935	848,810	0.6006	452,794	509,774
15	753,935	1,057,624	0.5775	435,379	610,752
16	753,935	1,127,229	0.5553	418,634	625,910
17	648,900	970,729	0.5339	346,453	518,280
18	917,787	471,675	0.5134	471,167	242,145
19	1,261,303	1,555,793	0.4936	622,615	767,983
20	0	0	0.4746	0	0
TOTAL=	$3,251,691	$7,170,535		$2,627,719	$5,995,739

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D9, p.15)
- GVW(lb)= 114,653
- Flywheel power (hp)= 460
- Universal blade

Loader (Caterpillar 988B, p.208)
- GVW(lb)= 85,560
- Flywheel power (hp)= 375
- Bucket size (cy)= 7

Motor Grader (Caterpillar 14G, p.79)
- GVW(lb)= 40,650
- Flywheel power (hp)= 150
- Standard 14' blade

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	1,020	99	412,086	1-18	7,416,115	12.166	5,012,470
Loader	1	405	77	159,162	1-18	2,864,909	12.166	1,936,360
Grader	1	N.A.	45	93,766	1-18	1,687,795	12.166	1,140,762
Total=				$664,934		$11,968,819		$8,089,592

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 8 hour days 260 days per year

TABLE 4
WASTE TRANSPORTATION COSTS
FOR
SITES 1 AND 6

EXPENDITURE	SITE 1 COSTS 1987 ($)	SITE 1 PRESENT WORTH	SITE 6 COSTS 1987 ($)	SITE 6 PRESENT WORTH
HAUL COSTS (TABLE 2)	3,251,691	2,627,719	7,170,535	5,995,739
LOAD/UNLOAD (TABLE 3)-*	23,937,638	16,179,184	23,937,638	16,179,184
TOTAL=	$27,189,329	$18,806,902	$31,108,173	$22,174,922

* - A COMPENSATION FACTOR HAS BEEN ADDED FOR LEVEL B WORKER PROCTECTON

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
250 THOUSAND CUBIC YARD CELLS (636' x 636' x 43' HIGH)
ESTIMATE IS BASED ON DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	696 acres	1000	696,000	0-17	25,752	12.166	509,640	535,392
Earthwork-cut	3,177,120 bcy	3	9,531,360	0-17	352,660	12.166	6,979,254	7,331,914
Earthwork-fill	3,667,440 bcy	3	11,002,320	0-17	407,086	12.166	8,056,351	8,463,437
Berms	11,366,640 bcy	3	34,099,920	0-17	1,261,697	12.166	24,969,364	26,231,061
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8' x 12' x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 sm	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	93,000 ft	50	4,650,000	0-17	0	12.166	3,535,744	3,535,744
Surface Water Control								
Ditch	140,640 ft	6	893,064	0-17	0	12.166	679,064	679,064
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	27,120 lf	20	542,400	0	542,400	1.000	0	542,400
								0
Cell Construction (250,000 cy cell)	64 ea	1,673,490	107,103,360	0-17	1,673,490	12.166	80,166,237	81,839,727
SUB TOTAL=			$169,188,424		$4,933,085			$129,828,738
Engineering design, plans and spec's (10% of total costs)			16,918,842		16,918,842			16,918,842
Contingency fund (15% of total costs)			25,378,264		25,378,264			25,378,264
Total =			$211,485,530		$47,230,191			$172,125,844

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE I

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	47,640	3	142,920	18	0.494	70,545
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	140,640	1	70,320	18	0.494	34,710
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$278,240			$137,339

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	211,485,530	172,125,844
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	278,240	137,339
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$250,600,099	$198,106,322

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
ONE MILLION CUBIC YARD CEL'S (1004' x 1004' x 43" HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	527 acres	1000	526,800	0-17	19,492	12.166	385,745	405,236
Earthwork-cut	3,721,164 bcy	3	11,163,492	0-17	413,049	12.166	8,174,368	8,587,417
Earthwork-fill	675,600 bcy	3	2,026,800	0-17	74,992	12.166	1,484,106	1,559,098
Berms	3,952,920 bcy	3	11,858,760	0-17	438,774	12.166	8,683,472	9,122,246
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8' x 12' x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	150,000
Maintenance Building (60' x 125')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	40,560 ft	50	2,028,000	0-17	0	12.166	1,542,041	1,542,041
Surface Water Control								
Ditch	68,640 ft	6	435,864	0-17	0	12.166	331,420	331,420
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	22,200 lf	20	444,000	0	444,000	1.000	0	444,000
								0
Cell Construction (1,000,000 cy cell)	16 ea	5,636,599	90,185,584	0-17	5,636,599	12.166	64,288,934	69,925,533
SUB TOTAL=			$119,339,300		$7,696,906			$92,586,991
Engineering design, plans and spec's (10% of total costs)			11,933,930		11,933,930			11,933,930
Contingency fund (15% of total costs)			17,900,895		17,900,895			17,900,895
Total =			$149,174,125		$37,531,731			$122,421,816

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,308

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	28,104	3	84,312	18	0.494	41,616
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	68,664	1	34,332	18	0.494	16,946
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$183,644			$90,647

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE I

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	149,174,125	122,421,816
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	103,644	90,647
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$188,194,098	$148,355,601

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
1.5 MILLION CUBIC YARD CELLS (1004' x 1004' x 68' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	378 acres	1000	378,000	0-17	13,986	12.166	276,787	290,773
Earthwork-cut	4,904,400 bcy	3	14,713,200	0-17	544,388	12.166	10,773,610	11,317.999
Earthwork-fill	154,200 bcy	3	462,600	0-17	17,116	12.166	338,735	355,851
Berms	5,760,000 bcy	3	17,280,000	0-17	639,360	12.166	12,653,127	13,292,487
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8'x 12'x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 sf	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	31,560 ft	50	1,578,000	0-17	0	12.166	1,199,872	1,199,872
Surface Water Control								
Ditch	48,360 ft	6	307,086	0-17	0	12.166	233,501	233,501
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	19,680 lf	20	393,600	0	393,600	1.000	0	393,600
								0
Cell Construction (1,500,000 cy cell)	10.667 ea	5,571,588	59,432,129	0-17	5,571,588	12.166	40,954,209	46,525,797
SUB TOTAL=			$95,214,615		$7,850,039			$74,279,879
Engineering design, plans and spec's (10% of total costs)			9,521,462		9,521,462			9,521,462
Contingency fund (15% of total costs)			14,282,192		14,282,192			14,282,192
Total =			$119,018,269		$31,653,692			$98,083,532

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* - Cost occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	16,800	3	50,400	18	0.494	24,877
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	48,360	1	24,180	18	0.494	11,935
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$139,580			$68,897

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	119,018,269	98,083,532
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	139,580	68,897
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$157,994,178	$123,995,567

* - Based on a 4% discount rate (Interest rate - Inflation rate)

20 YEAR BUILDOUT PERIOD - 9 CONCEPT DESIGN - THREE MILLION CUBIC YARD CELLS

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COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
9-CELL CONCEPT
THREE MILLION CUBIC YARD CELLS (1635' x 1635' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	497 acres	1000	496,000	0-17	18,382	12.166	363,777	382,159
Earthwork-cut	4,425,240 bcy	3	13,275,720	0-17	491,202	12.166	9,721,028	10,212,230
Earthwork-fill	1,312,440 bcy	3	3,937,320	0-17	145,681	12.166	2,883,060	3,028,740
Berms	3,704,520 bcy	3	11,113,560	0-17	411,202	12.166	8,137,805	8,549,007
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8' x 12' x 40')	2 ea	50,000	100,000	0	100,000	1.000	0	100,000
Maintenance Building (60' x 125')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	27,840 ft	50	1,392,000	0-17	0	12.166	1,058,442	1,058,442
Surface Water Control								
Ditch	41,760 ft	6	265,176	0-17	0	12.166	201,633	201,633
Detention Pond (200' x 200' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	21,360 lf	20	427,200	0	427,200	1.000	0	427,200
								0
Cell Construction (3,000,000 cy cell)	5.3 ea	15,698,305	83,201,017	0-17	15,698,305	12.166	51,327,374	67,025,679
SUB TOTAL=			$114,778,793		$17,861,971			$91,555,099
Engineering design, plans and spec's (10% of total costs)			11,477,879		11,477,879			11,477,879
Contingency fund (15% of total costs)			17,216,819		17,216,819			17,216,819
Total =			$143,473,491		$46,556,669			$120,249,797

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	13,920	3	41,760	18	0.494	20,613
Suction roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	41,760	1	20,880	18	0.494	10,306
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$127,640			$63,003

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	143,473,491	120,249,797
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	127,640	63,003
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$182,437,460	$146,155,939

* - Based on a 4% discount rate (Interest rate - Inflation rate)

Rocky Mountain Arsenal Task 27
Ebasco Services Inc.
Estimate of Waste Transportation Costs for a 30 Year Buildout Period

Notes:

Waste transportation costs are estimated in two parts: Haul costs (Table 2) and Loading/unloading costs (Table 3).
Waste Transportation Costs to sites 1 and 6 (Summation of tables 2 and 3) are presented in Table 4.
The first and last years of the buildout period are used for facility construction and closure,respectively.
Loading/unloading costs are uniform throughout the buildout period.
Equipment production rates are based on 50 minute hours (83% efficiency).
Equipment production rates were estimated from the 12ed. of the Caterpillar Performance Handbook.
Equipment costs are based on an hourly rental fee that includes overhead for a driver,a mechanic, fuel, maintenance and spare parts.
Rental costs include a discount for both a volume fleet and long term rental agreement.
Equipment rental costs were provided by EBASCO Constructors Inc.

HAUL COSTS

Haul costs are considered to be costs associated with the transportation of waste from the contamination site to the land disposal facility.
Haul costs are calculated individually for sections.
Waste volumes in sections were taken from the DALF or the Phase 1 Contamination Accessment Reports if available.
Table 1 provides an estimate of the fleet size and time required to transport waste from sections to disposal sites 1 & 6.
Haul distances were measured from the center of "sections" to the centroid of the disposal site via the existing road grids.
Haul costs depend on haul distances and thus vary over the buildout period.
Waste material is transported in end dump haul trucks (off-road size).
A summary of haul costs by sections are presented in table 1 for both sites 1 and 6..
The annual "haul costs" for transportation of waste material is presented in table 2.

Equipment Specifications

End dump haul truck (Caterpillar 769C, p.226)

Empty vehicle weight (EVW)	= 68,000lb
Gross vehicle weight (GVW)	=138,000lb
Payload	= 70,000lb or 35 tons
Capacity	= 22.8 cy (struck)

Estimation of haul truck production rates

Haul truck production rates are a function of the travel time to and from the contamination site and land disposal facility.
The total round trip travel time is the sum of the haul time, return time and load/unload time.
The haul times and return times can be estimated by equations 1 and 2 derived from the Caterpillar Handbook (p.233-234).
The load/unload time is an assumed constant.

Eq. (1) Haul time (min)= 0.22 + 4.81E-4(X) were X is in feet, based on the GVW and a total resistance of 4% (2% rolling + 2% grade)

Eq. (2) Return time (min)= 0.24 + 2.50E-4(X) were X is in feet, based on the EVW and 0% total resistance (2% rolling and -2% grade)

Input parameters for calculation of Table 1 and 2.

Waste placement years=	28	
Construction days per year=	260	(5 days/week-52 weeks/year)
Begin waste placement at end of year	1	
Load/unload time (minutes)=	2.15	
Hourly 765C rental fee ($)=	68.79	
Annual waste placement rate (BCY)=	476,257	

TABLE 1
Required fleet size for Transportation of waste
to sites 1 and 6

CLEAN UP PRIORITY	SECTION NO.	WASTE VOLUME (BCY)	HAUL DISTANCE SITE 1B	HAUL DISTANCE SITE 6	HAUL TIME (MIN) SITE 1B	HAUL TIME (MIN) SITE 6	RETURN TIME (MIN) SITE 1B	RETURN TIME (MIN) SITE 6	TOTAL TRAVEL TIME SITE 1B	TOTAL TRAVEL TIME SITE 6	PRODUCTION RATE (BCY/HR) SITE 1	PRODUCTION RATE (BCY/HR) SITE 6	REQUIRED FLEET SIZE SITE 1	REQUIRED FLEET SIZE SITE 6	YEAR OF CLEAN UP SITE 1 OR 6
1	26	3,996,000	3,100	16,800	1.71	8.30	1.02	4.44	5.15	16.15	179.45	57.17	1	4	1
2	36	3,630,700	7,380	11,560	3.77	5.78	2.09	3.13	8.58	11.94	107.57	77.33	2	3	9.390
3	1	2,185,800	13,700	15,840	6.81	7.84	3.67	4.20	13.66	15.38	67.60	60.04	3	4	17.014
4	2	1,715,800	13,700	22,120	6.81	10.86	3.67	5.77	13.66	20.42	67.60	45.21	3	5	21.603
5	25	47,300	2,100	11,520	1.23	5.76	0.77	3.12	4.34	11.91	212.65	77.53	1	3	25.286
6	35	122,000	8,420	16,840	4.27	8.32	2.35	4.45	9.42	16.18	98.03	57.06	2	4	25.385
7	24	96,000	8,420	16,800	4.27	8.30	2.35	4.44	9.42	16.15	98.03	57.17	2	4	25.562
8	19	1,000	12,660	11,560	6.31	5.78	3.41	3.13	12.83	11.94	72.00	77.33	3	3	25.763
9	20	1,000	17,940	11,560	8.85	5.78	4.73	3.13	17.07	11.94	54.11	77.33	4	3	25.765
10	30	163,600	12,710	6,240	6.33	3.22	3.42	1.80	12.87	7.67	71.77	120.42	3	2	25.767
11	29	34,200	17,990	4,240	8.87	2.26	4.74	1.30	17.11	6.06	53.98	152.34	4	2	26.111
12	31	169,000	12,500	6,240	6.23	3.22	3.37	1.80	12.70	7.67	72.73	120.42	3	2	26.183
13	32	140,000	17,980	4,240	8.87	2.26	4.74	1.30	17.10	6.06	54.00	152.34	4	2	26.537
14	5	147,000	24,260	11,520	11.89	5.76	6.31	3.12	22.14	11.91	41.70	77.53	5	3	26.831
15	6	97,000	18,940	11,520	9.33	5.76	4.98	3.12	17.87	11.91	51.67	77.53	4	3	27.140
16	12	244,000	18,990	22,080	9.35	10.84	4.99	5.76	17.91	20.39	51.56	45.28	4	5	27.344
17	11	53,000	16,300	27,360	8.06	13.38	4.32	7.08	15.75	24.63	58.63	37.49	4	6	27.856
18	3	47,800	18,990	27,400	9.35	13.40	4.99	7.09	17.91	24.67	51.56	37.44	4	6	27.967
19	4	444,000	29,540	37,960	14.43	18.48	7.63	9.73	26.38	33.15	35.00	27.86	7	8	28.068
															29.000
	Total=	13,335,200													

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	182,567	573,024	0.9615	175,545	550,985
3	182,567	573,024	0.9246	168,794	529,793
4	182,567	573,024	0.8890	162,302	509,417
5	182,567	573,024	0.8548	156,059	489,824
6	182,567	573,024	0.8219	150,057	470,984
7	182,567	573,024	0.7903	144,285	452,869
8	182,567	573,024	0.7599	138,736	435,451
9	182,567	573,024	0.7307	133,400	418,703
10	253,723	485,908	0.7026	178,263	341,392
11	304,549	423,682	0.6756	205,743	286,224
12	304,549	423,682	0.6496	197,829	275,215
13	304,549	423,682	0.6246	190,221	264,630
14	304,549	423,682	0.6006	182,904	254,452
15	304,549	423,682	0.5775	175,870	244,666
16	304,549	423,682	0.5553	169,105	235,255
17	304,549	423,682	0.5339	162,601	226,207
18	484,673	545,664	0.5134	248,818	280,129
19	484,673	545,664	0.4936	239,248	269,355
20	484,673	545,664	0.4746	230,046	258,995
21	484,673	545,664	0.4564	221,198	249,034
22	484,673	620,240	0.4388	212,691	272,182
23	484,673	724,647	0.4220	204,510	305,769
24	484,673	724,647	0.4057	196,644	294,008
25	484,673	724,647	0.3901	189,081	282,700
26	374,827	510,798	0.3751	140,604	191,609
27	571,932	273,389	0.3607	206,290	98,608
28	641,212	648,361	0.3468	222,383	224,862
29	911,064	1,151,015	0.3335	303,819	383,838
30	0	0	0.3207	0	0
TOTAL=	$1,714,261	$5,070,103		$1,407,441	$4,193,419

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D7G, p.15)	
GVW(lb)=	44,300
Flywheel power (hp)=	200
Universal blade	
Loader (Caterpillar 980C, p.287)	
GVW(lb)=	58,000
Flywheel power (hp)=	270
Bucket size (cy)=	5
Motor Grader (Caterpillar 12G, p.79)	
GVW(lb)=	29,525
Flywheel power (hp)=	135
Standard 10' blade	

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	900	61	254,800	1-28	7,134,400	16.663	4,245,732
Loader	2	200	54	225,306	1-28	6,308,557	16.663	3,754,267
Grader	1	N.A.	28	58,864	1-28	1,648,192	16.663	980,851
Total=				$538,970		$15,091,149		$8,980,850

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 8 hour days 260 days per year

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	283,993	891,371	0.9615	273,071	857,088
3	283,993	891,371	0.9246	262,568	824,123
4	283,993	891,371	0.8890	252,469	792,426
5	283,993	891,371	0.8548	242,759	761,948
6	283,993	891,371	0.8219	233,422	732,642
7	410,493	736,497	0.7903	324,419	582,065
8	473,744	659,060	0.7599	360,006	500,832
9	473,744	659,060	0.7307	346,160	481,569
10	473,744	659,060	0.7026	332,846	463,047
11	473,744	659,060	0.6756	320,044	445,238
12	660,538	785,560	0.6496	429,073	510,285
13	753,935	848,810	0.6246	470,906	530,165
14	753,935	848,810	0.6006	452,794	509,774
15	753,935	1,057,624	0.5775	435,379	610,752
16	753,935	1,127,229	0.5553	418,634	625,910
17	648,900	970,729	0.5339	346,453	518,280
18	917,787	471,675	0.5134	471,167	242,145
19	1,261,303	1,555,793	0.4936	622,615	767,983
20	0	0	0.4746	0	0
TOTAL=	$3,251,691	$7,170,535		$2,627,719	$5,995,739

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D9, p.15)

GVW(lb)=	114,653
Flywheel power (hp)=	460
Universal blade	

Loader (Caterpillar 988B, p.288)

GVW(lb)=	85,560
Flywheel power (hp)=	375
Bucket size (cy)=	7

Motor Grader (Caterpillar 14G, p.79)

GVW(lb)=	40,630
Flywheel power (hp)=	150
Standard 14' blade	

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	1,828	99	412,006	1-18	7,416,115	12.166	5,012,470
Loader	1	405	77	159,162	1-18	2,864,909	12.166	1,936,360
Grader	1	N.A.	45	93,766	1-18	1,687,795	12.166	1,140,762
Total=				$664,934		$11,968,819		$8,089,592

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 8 hour days 260 days per year

TABLE 4
WASTE TRANSPORTATION COSTS
FOR
SITES 1 AND 6

EXPENDITURE	SITE 1 COSTS 1987 ($)	SITE 1 PRESENT WORTH	SITE 6 COSTS 1987 ($)	SITE 6 PRESENT WORTH
HAUL COSTS (TABLE 2)	3,251,691	2,627,719	7,170,535	5,995,739
LOAD/UNLOAD (TABLE 3)-*	23,937,638	16,179,184	23,937,638	16,179,184
TOTAL=	$27,189,329	$18,806,902	$31,108,173	$22,174,922

* - A COMPENSATION FACTOR HAS BEEN ADDED FOR LEVEL B WORKER PROCTECTON

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
250 THOUSAND CUBIC YARD CELLS (636' x 636' x 43' HIGH)
ESTIMATE IS BASED ON DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	696 acres	1000	696,000	0-17	25,752	12.166	509,640	535,392
Earthwork-cut	3,177,120 bcy	3	9,531,360	0-17	352,660	12.166	6,979,254	7,331,914
Earthwork-fill	3,667,440 bcy	3	11,002,320	0-17	407,086	12.166	8,056,351	8,463,437
Berms	11,366,640 bcy	3	34,099,920	0-17	1,261,697	12.166	24,969,364	26,231,061
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8'x 12'x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	93,000 ft	50	4,650,000	0-17	0	12.166	3,535,744	3,535,744
Surface Water Control								
Ditch	140,640 ft	6	893,064	0-17	0	12.166	679,064	679,064
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	27,120 lf	20	542,400	0	542,400	1.000	0	542,400
								0
Cell Construction (250,000 cy cell)	64 ea	1,673,490	107,103,360	0-17	1,673,490	12.166	80,166,237	81,839,727
SUB TOTAL=			$169,188,424		$4,933,085			$129,828,738
Engineering design, plans and spec's (10% of total costs)			16,918,842		16,918,842			16,918,842
Contingency fund (15% of total costs)			25,378,264		25,378,264			25,378,264
Total =			$211,485,530		$47,230,191			$172,125,844

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	47,640	3	142,920	18	0.494	70,545
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	140,640	1	70,320	18	0.494	34,710
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$278,240			$137,339

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	211,485,530	172,125,844
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	278,240	137,339
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$250,600,099	$198,106,322

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
ONE MILLION CUBIC YARD CELLS (1004' x 1004' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	527 acres	1000	526,800	0-17	19,492	12.166	385,745	405,236
Earthwork-cut	3,721,164 bcy	3	11,163,492	0-17	413,049	12.166	8,174,368	8,587,417
Earthwork-fill	675,600 bcy	3	2,026,800	0-17	74,992	12.166	1,484,106	1,559,098
Berms	3,952,920 bcy	3	11,858,760	0-17	438,774	12.166	8,683,472	9,122,246
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8' x 12' x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 sa	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	40,560 ft	50	2,028,000	0-17	0	12.166	1,542,041	1,542,041
Surface Water Control								
Ditch	68,640 ft	6	435,864	0-17	0	12.166	331,420	331,420
Detention Pond (220' x 220' x 13')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	22,200 lf	20	444,000	0	444,000	1.000	0	444,000
								0
Cell Construction (1,000,000 cy cell)	16 ea	5,636,599	90,185,584	0-17	5,636,599	12.166	64,288,934	69,925,533
SUB TOTAL=			$119,339,300		$7,696,906			$92,586,991
Engineering design, plans and spec's (10% of total costs)			11,933,930		11,933,930			11,933,930
Contingency fund (15% of total costs)			17,900,895		17,900,895			17,900,895
Total =			$149,174,125		$37,531,731			$122,421,816

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	28,104	3	84,312	18	0.494	41,616
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	68,664	1	34,332	18	0.494	16,946
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$183,644			$90,647

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	149,174,125	122,421,816
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	183,644	90,647
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$188,194,098	$148,355,601

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
1.5 MILLION CUBIC YARD CELLS (1004' x 1004' x 68' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	378 acres	1000	378,000	0-17	13,986	12.166	276,787	290,773
Earthwork-cut	4,904,400 bcy	3	14,713,200	0-17	544,388	12.166	10,773,610	11,317,999
Earthwork-fill	154,200 bcy	3	462,600	0-17	17,116	12.166	338,735	355,851
Berms	5,760,000 bcy	3	17,280,000	0-17	639,360	12.166	12,653,127	13,292,487
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8'x 12'x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	31,560 ft	50	1,578,000	0-17	0	12.166	1,199,872	1,199,872
Surface Water Control								
Ditch	48,360 ft	6	307,086	0-17	0	12.166	233,501	233,501
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	19,680 lf	20	393,600	0	393,600	1.000	0	393,600
								0
Cell Construction (1,500,000 cy cell)	10.667 ea	5,571,588	59,432,129	0-17	5,571,588	12.166	40,954,209	46,525,797
SUB TOTAL=			$95,214,615		$7,850,039			$74,279,879
Engineering design, plans and spec's (10% of total costs)			9,521,462		9,521,462			9,521,462
Contingency fund (15% of total costs)			14,282,192		14,282,192			14,282,192
Total =			$119,018,269		$31,653,692			$98,083,532

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,508

* - Cost occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	16,800	3	50,400	18	0.494	24,877
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	48,360	1	24,180	18	0.494	11,935
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$139,580			$68,897

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	119,018,269	98,083,532
Operation & Main.(Table 2)	36,511,329	25,231,508
Closure (Table 3)	139,580	68,897
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$157,994,178	$123,995,567

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 20-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
THREE MILLION CUBIC YARD CELLS (1639' x 1639' x 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-20	PRESENT WORTH CONST. COSTS YRS 0-20
Site Preparation								
Clearing Grubbing	497 acres	1000	496,800	0-17	18,382	12.166	363,777	382,159
Earthwork-cut	4,425,240 bcy	3	13,275,720	0-17	491,202	12.166	9,721,028	10,212,230
Earthwork-fill	1,312,440 bcy	3	3,937,320	0-17	145,681	12.166	2,883,068	3,028,748
Berms	3,704,520 bcy	3	11,113,560	0-17	411,202	12.166	8,137,806	8,549,007
Support Buildings and Equipment								
Administration Building (40' x 45')	1,800 sq. ft	50	90,000	0	90,000	1.000	0	90,000
Personnel Decon. Trailer (8'x 12'x 40')	2 ea	90,000	180,000	0	180,000	1.000	0	180,000
Maintenance Building (60' x 125')	7,500 ea	20	150,000	0	150,000	1.000	0	150,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	27,840 ft	50	1,392,000	0-17	0	12.166	1,058,442	1,058,442
Surface Water Control								
Ditch	41,760 ft	6	265,176	0-17	0	12.166	201,633	201,633
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	21,360 lf	20	427,200	0	427,200	1.000	0	427,200 0
Cell Construction (3,000,000 cy cell)	5.3 ea	15,698,305	83,201,017	0-17	15,698,305	12.166	51,327,374	67,025,679
SUB TOTAL=			$114,778,793		$17,861,971			$91,555,099
Engineering design, plans and spec's (10% of total costs)			11,477,879		11,477,879			11,477,879
Contingency fund (15% of total costs)			17,216,819		17,216,819			17,216,819
Total =			$143,473,491		$46,556,669			$120,249,797

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	18	27,189,329	-	18,806,902
Dust Suppression	40,000	-	40,000	18	720,000	12.659	506,360
Support Buildings And Equipment							
Administration	2,000	500	2,500	20	50,000	13.59	33,975
Personnel Decon/clean Trailers	5,000	500	5,500	20	110,000	13.59	74,745
Haul/Access Roads	-	20,000	20,000	20	400,000	13.59	271,800
Surface Water Control System	-	5,000	5,000	20	100,000	13.59	67,950
Sampling monitoring wells (quarterly)	5,000	-	5,000	20	100,000	13.59	67,950
Administration Personnel							
1-Site Manager	55,000	-	55,000	20	1,100,000	13.59	747,450
1-Construction foreman	45,000	-	45,000	19	855,000	13.134	591,030
1-Facilities foreman	45,000	-	45,000	19	855,000	13.134	591,030
2-Laborers	60,000	-	60,000	20	1,200,000	13.59	815,400
1-QA/QC personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Health & Safety personnel	32,000	-	32,000	18	576,000	12.659	405,088
1-Field engineering support	35,000	-	35,000	18	630,000	12.659	443,065
1-Scale house technician	25,000	-	25,000	18	450,000	12.659	316,475
2-Security	60,000	-	60,000	20	1,200,000	13.59	815,400
1-secretary	20,000	-	20,000	20	400,000	13.59	271,800
TOTAL=					$36,511,329		$25,231,308

* -Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	18	0.494	7,404
Decontaminate Haul Roads						
Longitudinal roads on site 1	13,920	3	41,760	18	0.494	20,613
Section roads	15,000	3	45,000	18	0.494	22,212
Surface Water Control						
Ditch (Decon)	41,760	1	20,880	18	0.494	10,306
Pond (Remove)	1	5,000	5,000	18	0.494	2,468
		TOTAL=	$127,640			$63,003

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	7.892	11,838
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	7.892	7,892
Monitoring Wells	5,000	-	5,000	30	150,000	7.892	39,460
Administration Personnel							
Manager (part time)	45,000	-	45,000	30	1,350,000	7.892	355,140
Security Guard	25,000	-	25,000	30	750,000	7.892	197,300
TOTAL=					$2,325,000		$611,630

Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
20 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	143,473,491	120,249,797
Operation & Main. (Table 2)	36,511,329	25,231,508
Closure (Table 3)	127,640	63,003
Post Closure (Table 4)	2,325,000	611,630
TOTAL=	$182,437,460	$146,155,939

* - Based on a 4% discount rate (Interest rate - Inflation rate)

Rocky Mountain Arsenal Task 27
Ebasco Services Inc.
Estimate of Waste Transportation Costs for a 30 Year Buildout Period

Notes:

Waste transportation costs are estimated in two parts: Haul costs (Table 2) and Loading/unloading costs (Table 3).
Waste Transportation Costs to sites 1 and 6 (summation of tables 2 and 3) are presented in Table 4.
The first and last years of the buildout period are used for facility construction and closure,respectively.
Loading/unloading costs are uniform throughout the buildout period.
Equipment production rates are based on 50 minute hours (83% efficiency).
Equipment production rates were estimated from the 12ed. of the Caterpillar Performance Handbook.
Equipment costs are based on an hourly rental fee that includes overhead for a driver,a mechanic, fuel, maintenance and spare parts.
Rental costs include a discount for both a volume fleet and long term rental agreement.
Equipment rental costs were provided by EBASCO Constructors Inc.

HAUL COSTS

Haul costs are considered to be costs associated with the transportation of waste from the contamination site to the land disposal facility.
Haul costs are calculated individually for sections.
Waste volumes in sections were taken from the DALF or the Phase 1 Contamination Accessment Reports if available.
Table 1 provides an estimate of the fleet size and time required to transport waste from sections to disposal sites 1 & 6.
Haul distances were measured from the center of "sections" to the centroid of the disposal site via the existing road grids.
Haul costs depend on haul distances and thus vary over the buildout period.
Waste material is transported in end dump haul trucks (off-road size).
A summary of haul costs by sections are presented in table 1 for both sites 1 and 6..
The annual "haul costs" for transportation of waste material is presented in table 2.

Equipment Specifications

End dump haul truck (Caterpillar 769C, p.226)

Empty vehicle weight (EVW)	= 68,000lb
Gross vehicle weight (GVW)	=138,000lb
Payload	= 70,000lb or 35 tons
Capacity	= 22.8 cy (struck)

Estimation of haul truck production rates

Haul truck production rates are a function of the travel time to and from the contamination site and land disposal facility.
The total round trip travel time is the sum of the haul time, return time and load/unload time.
The haul times and return times can be estimated by equations 1 and 2 derived from the Caterpillar Handbook (p.233-234).
The load/unload time is an assumed constant.

Eq. (1) Haul time (min)= 0.22 + 4.81E-4(X) were X is in feet, based on the GVW and a total resistance of 4% (2% rolling + 2% grade)

Eq. (2) Return time (min)= 0.24 + 2.50E-4(X) were X is in feet, based on the EVW and 0% total resistance (2% rolling and -2% grade)

Input parameters for calculation of Table 1 and 2.

Waste placement years=	28	
Construction days per year=	260	(5 days/week-52 weeks/year)
Begin waste placement at end of year	1	
Load/unload time (minutes)=	2.15	
Hourly 769C rental fee ($)=	68.79	
Annual waste placement rate (BCY)=	476,257	

TABLE 1
Required fleet size for Transportation of waste
to sites 1 and 6

CLEAN UP PRIORITY	SECTION NO.	WASTE VOLUME (BCY)	HAUL DISTANCE SITE 1B	HAUL DISTANCE SITE 6	HAUL TIME (MIN) SITE 1B	HAUL TIME (MIN) SITE 6	RETURN TIME (MIN) SITE 1B	RETURN TIME (MIN) SITE 6	TOTAL TRAVEL TIME SITE 1B	TOTAL TRAVEL TIME SITE 6	PRODUCTION RATE(BCY/HR) SITE 1	PRODUCTION RATE(BCY/HR) SITE 6	REQUIRED FLEET SIZE SITE 1	REQUIRED FLEET SIZE SITE 6	YEAR OF CLEAN UP SITE 1 OR 6
1	26	3,996,000	3,100	16,800	1.71	8.30	1.02	4.44	5.15	16.15	179.45	57.17	1	4	1
2	36	3,630,700	7,380	11,560	3.77	5.78	2.09	3.13	8.58	11.94	107.57	77.33	2	3	9.390
3	1	2,185,800	13,700	15,840	6.81	7.84	3.67	4.20	13.66	15.38	67.60	60.04	3	4	17.014
4	2	1,715,800	13,700	22,120	6.81	10.86	3.67	5.77	13.66	20.42	67.60	45.21	3	5	21.603
5	25	47,300	2,100	11,520	1.23	5.76	0.77	3.12	4.34	11.91	212.65	77.53	1	3	25.206
6	35	122,000	8,420	16,840	4.27	8.32	2.35	4.45	9.42	16.18	98.03	57.06	2	4	25.305
7	24	96,000	8,420	16,800	4.27	8.30	2.35	4.44	9.42	16.15	98.03	57.17	2	4	25.562
8	19	1,000	12,660	11,560	6.31	5.78	3.41	3.13	12.83	11.94	72.00	77.33	3	3	25.763
9	20	1,000	17,940	11,560	8.85	5.78	4.73	3.13	17.07	11.94	54.11	77.33	4	3	25.765
10	30	163,600	12,710	6,240	6.33	3.22	3.42	1.80	12.87	7.67	71.77	120.42	3	2	25.767
11	29	34,200	17,990	4,240	8.87	2.26	4.74	1.30	17.11	6.06	53.98	152.34	4	2	26.111
12	31	169,000	12,500	6,240	6.23	3.22	3.37	1.80	12.70	7.67	72.73	120.42	3	2	26.183
13	32	140,000	17,980	4,240	8.87	2.26	4.74	1.30	17.10	6.06	54.00	152.34	4	2	26.537
14	5	147,000	24,260	11,520	11.89	5.76	6.31	3.12	22.14	11.91	41.70	77.53	5	3	26.831
15	6	97,000	18,940	11,520	9.33	5.76	4.98	3.12	17.87	11.91	51.67	77.53	4	3	27.140
16	12	244,000	18,990	22,080	9.35	10.84	4.99	5.76	17.91	20.39	51.56	45.28	4	5	27.344
17	11	53,000	16,300	27,360	8.06	13.38	4.32	7.09	15.75	24.63	58.63	37.49	4	6	27.856
18	3	47,800	18,990	27,400	9.35	13.40	4.99	7.09	17.91	24.67	51.56	37.44	4	6	27.967
19	4	444,000	29,540	37,960	14.43	18.48	7.63	9.73	26.38	33.15	35.00	27.86	7	8	28.068
															29.000
	Total=	13,335,200													

TABLE 2
ANNUAL HAUL COSTS
SITES 1 & 6

YEAR	1987 COST SITE 1	1987 COST SITE 6	PRESENT WORTH FACTOR	PRESENT WORTH SITE 1	PRESENT WORTH SITE 6
1	0	0	1	0	0
2	182,567	573,024	0.9615	175,545	550,985
3	182,567	573,024	0.9246	168,794	529,793
4	182,567	573,024	0.8890	162,302	509,417
5	182,567	573,024	0.8548	156,059	489,824
6	182,567	573,024	0.8219	150,057	470,984
7	182,567	573,024	0.7903	144,285	452,869
8	182,567	573,024	0.7599	138,736	435,451
9	182,567	573,024	0.7307	133,400	418,703
10	253,723	485,908	0.7026	178,263	341,392
11	304,549	423,682	0.6756	205,743	286,224
12	304,549	423,682	0.6496	197,829	275,215
13	304,549	423,682	0.6246	190,221	264,630
14	304,549	423,682	0.6006	182,904	254,452
15	304,549	423,682	0.5775	175,870	244,666
16	304,549	423,682	0.5553	169,105	235,255
17	304,549	423,682	0.5339	162,601	226,207
18	484,673	545,664	0.5134	248,818	280,129
19	484,673	545,664	0.4936	239,248	269,355
20	484,673	545,664	0.4746	230,046	258,995
21	484,673	545,664	0.4564	221,198	249,034
22	484,673	620,240	0.4388	212,691	272,182
23	484,673	724,647	0.4220	204,510	305,769
24	484,673	724,647	0.4057	196,644	294,008
25	484,673	724,647	0.3901	189,081	282,700
26	374,827	510,798	0.3751	140,604	191,609
27	571,932	273,389	0.3607	206,290	98,608
28	641,212	648,361	0.3468	222,383	224,862
29	911,064	1,151,015	0.3335	303,819	383,838
30	0	0	0.3207	0	0
TOTAL=	$1,714,261	$5,070,103		$1,407,441	$4,199,419

LOAD/UNLOAD COSTS

Load costs are costs associated with placement of waste in haul trucks.
Unload costs are costs associated with placement and compaction of the waste at the land disposal facility.
Load costs are based on a dozer to windrow waste material and a loader to place the waste in a haul truck.
Placement costs are based on a dozer and motor grader to move, level and compact the material at the land disposal facility.
Load/unload costs are proportional to the waste placement rate and therefore are uniform.
A summary of annual load/unload costs are presented in table 3.

Equipment Specifications

Dozer (Caterpillar D76, p.15)	
GVW(lb)=	44,300
Flywheel power (hp)=	200
Universal blade	
Loader (Caterpillar 980C, p.287)	
GVW(lb)=	58,000
Flywheel power (hp)=	270
Bucket size (cy)=	5
Motor Grader (Caterpillar 12G, p.79)	
GVW(lb)=	29,525
Flywheel power (hp)=	135
Standard 10' blade	

TABLE 3
ANNUAL LOAD/UNLOAD COSTS -*

EQUIPMENT	NO. REQUIRED	HOURLY PROD. RATE (BCY)	HOURLY RENTAL ($)	ANNUAL-** RENTAL ($)	YEARS OF OPERATION	COSTS 1987 ($)	PRESENT WORTH FACTOR	PRESENT WORTH
Dozer	2	900	61	254,800	1-28	7,134,400	16.663	4,245,732
Loader	2	200	54	225,306	1-28	6,308,557	16.663	3,754,267
Grader	1	N.A.	28	58,864	1-28	1,648,192	16.663	980,851
Total=				$538,970		$15,091,149		$8,980,850

* - Load/unload costs are the same for sites 1 and 6
* * - Based on 8 hour days 260 days per year

TABLE 4
WASTE TRANSPORTATION COSTS
FOR
SITES 1 AND 6

EXPENDITURE	SITE 1 COSTS 1987 ($)	SITE 1 PRESENT WORTH	SITE 6 COSTS 1987 ($)	SITE 6 PRESENT WORTH
HAUL COSTS (TABLE 2)	1,714,261	1,407,441	5,070,103	4,199,419
LOAD/UNLOAD (TABLE 3)-*	30,182,298	17,961,701	30,182,298	17,961,701
TOTAL=	$31,896,558	$19,369,142	$35,252,401	$22,161,120

* - A COMPENSATION FACTOR IS ADDED FOR LEVEL B WORKER PROTECTION

COST ESTIMATE FOR 30-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
250,000 CUBIC YARD CELLS (636' x 636' x 43' HIGH)
ESTIMATE IS BASED ON DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-29	PRESENT WORTH CONST. COSTS YRS 0-29
Site Preparation								
Clearing Grubbing	696 acres	1000	696,000	0-27	24,857	15.983	397,292	422,149
Earthwork-cut	3,177,120 bcy	3	9,531,360	0-27	340,406	15.983	5,440,705	5,781,110
Earthwork-fill	3,667,440 bcy	3	11,002,320	0-27	392,940	15.983	6,280,360	6,673,300
Berms	11,366,640 bcy	3	34,099,920	0-27	1,217,854	15.983	19,464,965	20,682,819
Support Buildings and Equipment								
Administration Building (60' x 20')	1,200 sq. ft	50	60,000	0	60,000	1.000	0	60,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 100')	6,000 ea	20	120,000	0	120,000	1.000	0	120,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	93,000 ft	50	4,650,000	0-27	0	15.983	2,752,628	2,752,628
Surface Water Control								
Ditch	117,200 ft	6	744,220	0-27	0	15.983	440,551	440,551
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	27,120 lf	20	542,400	0	542,400	1.000	0	542,400 0
Cell Construction (250,000 cy cell)	64 ea	1,673,490	107,103,360	0-27	9,099,023	15.983	58,014,938	67,113,961
SUB TOTAL=			$169,069,580		$12,317,480			$105,108,918
Engineering design, plans and spec's (10% of total costs)			16,906,958		16,906,958			16,906,958
Contingency fund (15% of total costs)			25,360,437		25,360,437			25,360,437
Total =			$211,336,975		$54,584,875			$147,376,313

* - Construction costs occur at years end.
** - Initial construction costs are onsidered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	28	31,896,558	-	19,369,142
Dust Suppression	40,000	-	40,000	28	1,120,000	16.63	665,200
Support Buildings And Equipment							
Administration	2,000	500	2,500	30	75,000	17.292	43,230
Personnel Decon/clean Trailers	5,000	500	5,500	30	165,000	17.292	95,106
Haul/Access Roads	-	20,000	20,000	30	600,000	17.292	345,840
Surface Water Control System	-	5,000	5,000	30	150,000	17.292	86,460
Sampling monitoring wells (quarterly)	5,000	-	5,000	30	150,000	17.292	86,460
Administration Personnel							
1-Site Manager	55,000	-	55,000	30	1,650,000	17.292	951,060
1-Construction foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
1-Facilities foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
2-Laborers	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-QA/QC personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Health & Safety personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Field engineering support	35,000	-	35,000	28	980,000	16.63	582,050
1-Scale house technician	25,000	-	25,000	28	700,000	16.63	415,750
2-Security	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-secretary	20,000	-	20,000	30	600,000	17.292	345,840
TOTAL=					$46,178,558		$27,681,778

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	28	0.334	5,003
Decontaminate Haul Roads						
Longitudinal roads on site 1	47,640	3	142,920	28	0.334	47,664
Section roads	15,000	3	45,000	28	0.334	15,008
Surface Water Control						
Ditch (Decon)	140,640	1	70,320	28	0.334	23,452
Pond (Remove)	1	5,000	5,000	28	0.334	1,668
		TOTAL=	$278,240			$92,793

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	5.331	7,997
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	5.331	5,331
Monitoring Wells	5,000	-	5,000	30	150,000	5.331	26,655
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	5.331	133,275
Security Guard	15,000	-	15,000	30	450,000	5.331	79,965
TOTAL=					$1,425,000		$253,223

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
30 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	211,336,975	147,376,313
Operation & Main. (Table 2)	46,178,558	27,681,778
Closure (Table 3)	278,240	92,793
Post Closure (Table 4)	1,425,000	253,223
TOTAL=	$259,218,773	$175,404,106

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 30-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
ONE MILLION CUBIC YARD CELLS (1004' X 1004' X 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-29	PRESENT WORTH CONST. COSTS YRS 0-29
Site Preparation								
Clearing Grubbing	527 acres	1000	526,800	0-27	18,814	15.983	300,709	319,523
Earthwork-cut	3,721,164 bcy	3	11,163,492	0-27	398,696	15.983	6,372,360	6,771,057
Earthwork-fill	675,600 bcy	3	2,026,800	0-27	72,386	15.983	1,156,941	1,229,327
Berms	3,952,920 bcy	3	11,858,760	0-27	423,527	15.983	6,769,234	7,192,761
Support Buildings and Equipment								
Administration Building (60' x 20')	1,200 sq. ft	50	60,000	0	60,000	1.000	0	60,000
Personnel Decon. Trailer (8'x 12'x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 100')	6,000 ea	20	120,000	0	120,000	1.000	0	120,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	40,560 ft	50	2,028,000	0-27	0	15.983	1,200,501	1,200,501
Surface Water Control								
Ditch	68,640 ft	6	435,864	0-27	0	15.983	258,015	258,015
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	22,200 lf	20	444,000	0	444,000	1.000	0	444,000
								0
Cell Construction (1,000,000 cy cell)	16 ea	5,636,599	90,185,584	0-27	3,099,023	15.983	48,000,241	57,099,264
SUB TOTAL=			$119,369,300		$11,156,446			$75,214,448
Engineering design, plans and spec's (10% of total costs)			11,936,930		11,936,930			11,936,930
Contingency fund (15% of total costs)			17,905,395		17,905,395			17,905,395
Total =			$149,211,625		$40,998,771			$105,056,773

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (Interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	28	31,896,558	-	19,369,142
Dust Suppression	40,000	-	40,000	28	1,120,000	16.63	665,200
Support Buildings And Equipment							
Administration	2,000	500	2,500	30	75,000	17.292	43,230
Personnel Decon/clean Trailers	5,000	500	5,500	30	165,000	17.292	95,106
Haul/Access Roads	-	20,000	20,000	30	600,000	17.292	345,840
Surface Water Control System	-	5,000	5,000	30	150,000	17.292	86,460
Sampling monitoring wells (quarterly)	5,000	-	5,000	30	150,000	17.292	86,460
Administration Personnel							
1-Site Manager	55,000	-	55,000	30	1,650,000	17.292	951,060
1-Construction foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
1-Facilities foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
2-Laborers	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-QA/QC personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Health & Safety personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Field engineering support	35,000	-	35,000	28	980,000	16.63	582,050
1-Scale house technician	25,000	-	25,000	28	700,000	16.63	415,750
2-Security	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-secretary	20,000	-	20,000	30	600,000	17.292	345,840
TOTAL=					$46,178,558		$27,681,778

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	28	0.334	5,003
Decontaminate Haul Roads						
Longitudinal roads on site 1	28,104	3	84,312	28	0.334	28,118
Section roads	15,000	3	45,000	28	0.334	15,008
Surface Water Control						
Ditch (Decon)	68,664	1	34,332	28	0.334	11,450
Pond (Remove)	1	5,000	5,000	28	0.334	1,668
		TOTAL=	$183,644			$61,245

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	5.331	7,997
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	5.331	5,331
Monitoring Wells	5,000	-	5,000	30	150,000	5.331	26,655
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	5.331	133,275
Security Guard	15,000	-	15,000	30	450,000	5.331	79,965
TOTAL=					$1,425,000		$253,223

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
30 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	149,211,625	105,056,773
Operation & Main. (Table 2)	46,178,558	27,681,778
Closure (Table 3)	183,644	61,245
Post Closure (Table 4)	1,425,000	253,223
TOTAL=	$196,998,827	$133,053,018

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 30-YEAR BUILDOUT ON PRIMARY SITE
9-CELL CONCEPT
ONE & ONE HALF MILLION CUBIC YARD CELLS (1004' X 1004, X 68' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-29	PRESENT WORTH CONST. COSTS YRS 0-29
Site Preparation								
Clearing Grubbing	378 acres	1000	378,000	0-27	13,500	15.983	215,771	229,271
Earthwork-cut	4,904,400 bcy	3	14,713,200	0-27	525,471	15.983	8,398,610	8,924,081
Earthwork-fill	154,200 bcy	3	462,600	0-27	16,521	15.983	264,062	280,583
Berms	5,760,000 bcy	3	17,280,000	0-27	617,143	15.983	9,863,794	10,480,937
Support Buildings and Equipment								
Administration Building (60' x 20')	1,200 sq. ft	50	60,000	0	60,000	1.000	0	60,000
Personnel Decon. Trailer (8' x 12' x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 100')	6,000 ea	20	120,000	0	120,000	1.000	0	120,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	31,560 ft	50	1,578,000	0-27	0	15.983	934,118	934,118
Surface Water Control								
Ditch	48,350 ft	6	307,086	0-27	0	15.983	181,784	181,784
Detention Pond (220' x 220' x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200' x 200' x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	19,680 lf	20	393,600	0	393,600	1.000	0	393,600 0
Cell Construction (1,500,000 cy cell)	10.667 ea	5,571,500	59,432,129	0-27	9,099,023	15.983	29,795,335	38,894,358
SUB TOTAL=			$95,244,615		$11,363,259			$61,018,731
Engineering design, plans and spec's (10% of total costs)			9,524,462		9,524,462			9,524,462
Contingency fund (15% of total costs)			14,286,692		14,286,692			14,286,692
Total =			$119,055,769		$35,176,413			$84,829,885

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	28	31,896,558	-	19,369,142
Dust Suppression	40,000	-	40,000	28	1,120,000	16.63	665,200
Support Buildings And Equipment							
Administration	2,000	500	2,500	30	75,000	17.292	43,230
Personnel Decon/clean Trailers	5,000	500	5,500	30	165,000	17.292	95,106
Haul/Access Roads	-	20,000	20,000	30	600,000	17.292	345,840
Surface Water Control System	-	5,000	5,000	30	150,000	17.292	86,460
Sampling monitoring wells (quarterly)	5,000	-	5,000	30	150,000	17.292	86,460
Administration Personnel							
1-Site Manager	55,000	-	55,000	30	1,650,000	17.292	951,060
1-Construction foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
1-Facilities foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
2-Laborers	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-QA/QC personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Health & Safety personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Field engineering support	35,000	-	35,000	28	980,000	16.63	582,050
1-Scale house technician	25,000	-	25,000	28	700,000	16.63	415,750
2-Security	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-secretary	20,000	-	20,000	30	600,000	17.292	345,840
TOTAL=					$46,178,558		$27,681,778

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-inflation)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	28	0.334	5,003
Decontaminate Haul Roads						
Longitudinal roads on site 1	16,800	3	50,400	28	0.334	16,808
Section roads	15,000	3	45,000	28	0.334	15,008
Surface Water Control						
Ditch (Decon)	48,360	1	24,180	28	0.334	8,064
Pond (Remove)	1	5,000	5,000	28	0.334	1,668
		TOTAL=	$139,580			$46,550

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	5.331	7,997
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	5.331	5,331
Monitoring Wells	5,000	-	5,000	30	150,000	5.331	26,655
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	5.331	133,275
Security Guard	15,000	-	15,000	30	450,000	5.331	79,965
TOTAL=					$1,425,000		$253,223

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
30 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	119,055,769	84,829,885
Operation & Main. (Table 2)	46,178,558	27,681,778
Closure (Table 3)	139,580	46,550
Post Closure (Table 4)	1,425,000	253,223
TOTAL=	$166,798,907	$112,811,435

* - Based on a 4% discount rate (Interest rate - Inflation rate)

COST ESTIMATE FOR 30-YEAR BUILDOUT ON PRIMARY SITE
B-CELL CONCEPT
THREE MILLION CUBIC YARD CELLS (1639' X 1639' X 43' HIGH)
ESTIMATE IS BASED ON THE DISPOSAL OF 16 MILLION CY OF MATERIAL

TABLE 1
CONSTRUCTION COSTS
SITE 1

ITEM	QUANTITY/ UNIT	UNIT PRICE ($)	TOTAL COST 1987 ($)	YEAR(S)-* CONST. COST OCCURS	INITIAL-** CONST. 1987 ($)	PRESENT-*** WORTH FACTOR	PRESENT WORTH CONST. COSTS YRS 1-29	PRESENT WORTH CONST. COSTS YRS 0-29
Site Preparation								
Clearing Grubbing	497 acres	1000	496,800	0-27	17,743	15.983	283,584	301,327
Earthwork-cut	4,425,240 bcy	3	13,275,720	0-27	474,133	15.983	7,578,065	8,052,198
Earthwork-fill	1,312,440 bcy	3	3,937,320	0-27	140,619	15.983	2,247,507	2,388,125
Berms	3,704,520 bcy	3	11,113,560	0-27	396,913	15.983	6,343,858	6,740,771
Support Buildings and Equipment								
Administration Building (60' x 20')	1,200 sq. ft	50	60,000	0	60,000	1.000	0	60,000
Personnel Decon. Trailer (8'x 12'x 40')	3 ea	90,000	270,000	0	270,000	1.000	0	270,000
Maintenance Building (60' x 100')	6,000 ea	20	120,000	0	120,000	1.000	0	120,000
Sampling laboratory (20' x 20')	400 sq. ft	225	90,000	0	90,000	1.000	0	90,000
Haul roads site 1	27,840 ft	50	1,392,000	0-27	0	15.983	824,012	824,012
Surface Water Control								
Ditch	41,760 ft	6	265,176	0-27	0	15.983	156,974	156,974
Detention Pond (220'x 220'x 15')	1 ea	40,000	40,000	0	40,000	1.000	0	40,000
Leachate evaporation pond (200'x 200'x 5')	1 ea	110,000	110,000	0	110,000	1.000	0	110,000
Monitoring Wells	5 ea	2,000	10,000	0	10,000	1.000	0	10,000
Security Fence	21,360 lf	20	427,200	0	427,200	1.000	0	427,200
								0
Cell Construction (3,000,000 cy cell)	5.3 ea	15,698,305	83,201,017	0-27	9,099,023	15.983	43,865,636	52,964,659
SUB TOTAL=			$114,808,793		$11,255,630			$72,535,267
Engineering design, plans and spec's (10% of total costs)			11,480,879		11,480,879			11,480,879
Contingency fund (15% of total costs)			17,221,319		17,221,319			17,221,319
Total =			$143,510,991		$39,957,828			$101,237,465

* - Construction costs occur at years end.
** - Initial construction costs are considered to be expenditures occurred during the first 12 months of operation (years 0 - 1).
*** - Based on a 4% discount rate (interest rate - inflation rate)

TABLE 3
CLOSURE COSTS
SITE 1

ITEM	QUANTITY	UNIT COST	TOTAL COST	YEAR-* OF EXPENDITURE	PRESENT-** WORTH FACTOR	PRESENT WORTH
Support Buildings And Equipment						
Decon. Personnel Trailers	3	5,000	15,000	28	0.334	5,003
Decontaminate Haul Roads						
Longitudinal roads on site 1	13,920	3	41,760	28	0.334	13,927
Section roads	15,000	3	45,000	28	0.334	15,008
Surface Water Control						
Ditch (Decon)	41,760	1	20,880	28	0.334	6,963
Pond (Remove)	1	5,000	5,000	28	0.334	1,668
		TOTAL=	$127,640			$42,568

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 4
POST CLOSURE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M	YEARS-* OF O&M	TOTAL O&M	PRESENT-** WORTH FACTOR	PRESENT WORTH OF O&M
Support Buildings And Equipment							
Administration Building	1,000	500	1,500	30	45,000	5.331	7,997
Surface Water Control System							
Ditch	-	1,000	1,000	30	30,000	5.331	5,331
Monitoring Wells	5,000	-	5,000	30	150,000	5.331	26,655
Administration Personnel							
Manager (part time)	25,000	-	25,000	30	750,000	5.331	133,275
Security Guard	15,000	-	15,000	30	450,000	5.331	79,965
TOTAL=					$1,425,000		$253,223

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 5
COST SUMMARY
30 YEAR BUILDOUT
SITE 1

COSTS	CONST. COSTS 1987 ($)	PRESENT-* WORTH
Construction (Table 1)	143,510,991	101,257,465
Operation & Main.(Table 2)	46,178,558	27,681,778
Closure (Table 3)	127,640	42,568
Post Closure (Table 4)	1,425,000	253,223
TOTAL=	$191,242,189	$129,235,033

* - Based on a 4% discount rate (Interest rate - Inflation rate)

TABLE 2
OPERATION AND MAINTENANCE COSTS
SITE 1

ITEM	OPERATION COSTS	MAINTENANCE COSTS	TOTAL O&M 1987 ($)	YEARS-* OF O&M	TOTAL COST	PRESENT -** WORTH FACTOR	PRESENT WORTH O&M
Waste transportation cost (Table 4)	-	-	-	28	31,896,558	-	19,369,142
Dust Suppression	40,000	-	40,000	28	1,120,000	16.63	665,200
Support Buildings And Equipment							
Administration	2,000	500	2,500	30	75,000	17.292	43,230
Personnel Decon/clean Trailers	5,000	500	5,500	30	165,000	17.292	95,106
Haul/Access Roads	-	20,000	20,000	30	600,000	17.292	345,840
Surface Water Control System	-	5,000	5,000	30	150,000	17.292	86,460
Sampling monitoring wells (quarterly)	5,000	-	5,000	30	150,000	17.292	86,460
Administration Personnel							
1-Site Manager	55,000	-	55,000	30	1,650,000	17.292	951,060
1-Construction foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
1-Facilities foreman	45,000	-	45,000	30	1,350,000	17.292	778,140
2-Laborers	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-QA/QC personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Health & Safety personnel	32,000	-	32,000	28	896,000	16.63	532,160
1-Field engineering support	35,000	-	35,000	28	980,000	16.63	582,050
1-Scale house technician	25,000	-	25,000	28	700,000	16.63	415,750
2-Security	60,000	-	60,000	30	1,800,000	17.292	1,037,520
1-secretary	20,000	-	20,000	30	600,000	17.292	345,840
TOTAL=					$46,178,558		$27,681,778

* - Costs occur at years end
** - Based on a 4% discount rate (Interest rate-Inflation)

TABLE I
SUMMARY OF CELL CONSTRUCTIONS COST
FOR B CONCEPT DESIGN

ITEM		UNIT	QUANTITY				UNIT PRICE ($)	CELL CONSTRUCTION COSTS ($)			
			CELL SIZE (CY)					CELL SIZE (CY)			
			250,000	1,000,000	1,500,000	3,000,000		250,000	1,000,080	1,500,000	3,000,000
Liner sys.											
Layer No.											
1	Filter Fabric	sf	253,705	891,097	895,714	2,518,927	0.18	45,667	160,397	161,228	453,407
2	Sand 12"	cy	9,396	33,004	33,175	93,294	12.00	112,758	396,043	398,095	1,119,523
3	Clay barrier 36"	cy	30,887	103,724	104,453	287,540	8.00	247,097	829,794	835,625	2,300,319
4	Sand 12"	cy	10,936	35,752	35,995	97,810	12.00	131,230	429,029	431,945	1,173,718
5	HDPE	sf	296,586	970,261	974,877	2,651,114	0.75	222,439	727,696	731,158	1,988,335
6	Geo-net	sf	296,586	970,261	974,877	2,651,114	0.17	50,420	164,944	165,729	450,689
7	Filter Fabric	sf	296,586	970,261	974,877	2,651,114	0.18	53,385	174,647	175,478	477,200
8	Soil Cap 36"	cy	34,471	110,533	111,046	299,062	4.00	137,885	442,134	444,186	1,196,250
9	Revegetation	ac	323,897	1,019,342	1,023,959	2,732,009	0.03	9,069	28,542	28,671	76,496
	SUB TOTAL=							$1,009,951	$3,353,226	$3,372,115	$9,235,939
Cover Sys.											
Layer No.											
1	Filter Fabric	sf	260,744	904,908	870,295	2,542,634	0.18	46,934	162,883	156,653	457,674
2	Geo-net	sf	260,744	904,908	870,295	2,542,634	0.17	44,326	153,834	147,950	432,248
3	HDPE	lf	260,744	904,908	870,295	2,542,634	0.75	195,558	678,681	652,721	1,906,976
4	Sand 12"	cy	9,670	33,528	32,255	94,185	12.00	116,042	402,337	387,059	1,130,216
5	Clay barrier 36"	cy	30,135	102,637	98,818	285,962	8.00	241,082	821,093	790,545	2,287,694
	SUB TOTAL=							$643,942	$2,218,828	$2,134,928	$6,214,807
Leachate System											
1	HDPE Pipe (4")	lf	5,451	20,196	20,196	84,423	2.50	13,628	50,490	50,490	211,058
2	Collection Sump	cf	588	1,722	1,722	6,200	2.50	1,469	4,306	4,306	15,501
3	Clean outs	ea	6	13	13	28	750.00	4,500	9,750	9,750	21,000
	SUBTOTAL=							$19,596	$64,545	$64,545	$247,559
	TOTAL =							$1,673,490	$5,636,599	$5,571,588	$15,698,305

Todd Wa
01-Jun-87
Ebasco Services Incorporated
Rocky Mountain Arsenal - Task 27

Material Quantities for B-Concept Design

Side slope, Upper = 4H:1V, Lower = 3H:1V
Total depth of waste = 35 ft

Cell Size = 250,000 cy	
Length of waste at grade, ft.	500
Length of cell at grade, ft.	564
Width at top of fill, B =	360
Width at bottom of cell, Bt =	395

Cell Cover:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	72.15	500.00	31,026.37	-	253,705	0.18	45,666.99
2	Sand	1	72.15	500.00	31,026.37	1,149.12	9,396	12.00	112,757.99
3	Compacted Clay	3	76.28	508.00	33,104.42	4,121.79	30,887	8.00	247,097.23
4	Sand	1	88.65	532.00	41,087.78	1,533.97	10,936	12.00	131,230.42
5	HDPE	-	92.77	540.00	41,746.44	-	296,586	0.75	222,439.33
6	Geo-net	-	92.77	540.00	41,746.44	-	296,586	0.17	50,419.58
7	Filter Fabric	-	92.77	540.00	41,746.44	-	296,586	0.18	53,385.44
8	Soil Cap	3	92.77	540.00	41,746.44	5,017.82	34,471	4.00	137,885.11
9	Revegetation	-	105.14	564.00	48,574.31	-	323,897	0.03	9,069.12
								Cover Cost	1,009,951.22

Cell Liner:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	58.50	500.00	26,179.71	-	260,744	0.18	46,933.89
2	Geo-net	-	58.50	500.00	26,179.71	-	260,744	0.17	44,326.45
3	HDPE	-	58.50	500.00	26,179.71	-	260,744	0.75	195,557.87
4	Sand	1	58.50	500.00	26,179.71	972.87	9,670	12.00	116,042.15
5	Compacted Clay	3	58.50	506.00	26,355.21	3,199.79	30,135	8.00	241,082.03
-	Bottom of Clay	-	67.99	524.00	31,240.93	-	-		
								Liner Cost	643,942.39
								Fill Cost	137,468.00
								PVC Pipe	30,275.00
								Total/Cell	1,821,636.61
								Total	116,584,743.18

Cell S[illegible] 1,000,[illegible]
Length of waste at grade, ft. 940
Length of cell at grade, ft. 1004
Width at top of fill, B = 800
Width at bottom of cell, Bt = 835

Cell Cover:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	72.15	940.00	62,774.28	-	891,097	0.18	160,397.48
2	Sand	1	72.15	940.00	62,774.28	2,324.97	33,004	12.00	396,043.17
3	Compacted Clay	3	76.28	948.00	66,666.49	8,153.27	103,724	8.00	829,793.52
4	Sand	1	88.65	972.00	80,092.36	3,012.18	35,752	12.00	429,028.93
5	HDPE	-	92.77	980.00	82,565.19	-	970,261	0.75	727,695.57
6	Geo-net	-	92.77	980.00	82,565.19	-	970,261	0.17	164,944.33
7	Filter Fabric	-	92.77	980.00	82,565.19	-	970,261	0.18	174,646.94
8	Soil Cap	3	92.77	980.00	82,565.19	9,855.60	110,533	4.00	442,133.99
9	Revegetation	-	105.14	1,004.00	94,835.55	-	1,019,342	0.03	28,541.58
								Cover Cost	3,353,225.51

Cell Liner:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	58.50	940.00	51,920.65	-	904,908	0.18	162,883.37
2	Geo-net	-	58.50	940.00	51,920.65	-	904,908	0.17	153,834.29
3	HDPE	-	58.50	940.00	51,920.65	-	904,908	0.75	678,680.69
4	Sand	1	58.50	940.00	51,920.65	1,926.24	33,528	12.00	402,337.15
5	Compacted Clay	3	58.50	946.00	52,096.15	6,291.79	102,637	8.00	821,092.86
-	Bottom of Clay	-	67.99	964.00	61,156.08	-	-		
								Liner Cost	2,218,828.35
								Fill Cost	137,468.00
								PVC Pipe	30,275.00
								Total/Cell	5,739,796.87
								Total	367,346,999.44

Cell Size = 1,558,222

Length of waste at grade, ft. 940
Length of cell at grade, ft. 1004
Width at top of fill, B = 700
Width at bottom of cell, Bt = 712

Cell Cover:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4	Sand	1	140.19	972.00	118,036.27	4,430.66	35,871	12.00	430,449.40
5	HDPE	-	144.31	980.00	121,219.31	-	974,877	0.75	731,157.92
6	Geo-net	-	144.31	980.00	121,219.31	-	974,877	0.17	165,729.13
7	Filter Fabric	-	144.31	980.00	121,219.31	-	974,877	0.18	175,477.90
8	Soil Cap	3	144.31	980.00	121,219.31	14,150.50	111,046	4.00	444,185.75
9	Revegetation	-	156.68	1,004.00	133,489.67	-	1,023,959	0.03	28,670.84
								Cover Cost	3,367,628.77

Cell Liner:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	98.03	940.00	80,973.28	-	830,837	0.18	149,550.68
2	Geo-net	-	98.03	940.00	80,973.28	-	830,837	0.17	141,242.31
3	HDPE	-	98.03	940.00	80,973.28	-	830,837	0.75	623,127.85
4	Sand	1	98.03	940.00	80,973.28	3,004.46	30,794	12.00	369,522.36
5	Compacted Clay	3	98.03	946.00	81,267.37	9,520.39	94,409	8.00	755,269.31
-	Bottom of Clay	-	107.52	964.00	90,099.62	-	-		
								Liner Cost	2,038,712.51
								Fill Cost	137,468.00
								PVC Pipe	30,275.00
								Total/Cell	5,574,084.28
								Total	356,741,393.87
								Total	81,316,810.01

Cell Size = 3,000,000 cy

Length of waste at grade, ft.	1583
Length of cell at grade, ft.	1647
Width at top of fill, B =	1443
Width at bottom of cell, Bt =	1478

Cell Cover:

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	72.15	1,583.00	109,169.53	-	2,518,927	0.18	453,406.88
2	Sand	1	72.15	1,583.00	109,169.53	4,043.32	93,294	12.00	1,119,523.16
3	Compacted Clay	3	76.28	1,591.00	115,712.90	14,044.73	287,540	8.00	2,300,319.34
4	Sand	1	88.65	1,615.00	137,092.23	5,172.38	97,810	12.00	1,173,718.18
5	HDPE	-	92.77	1,623.00	142,216.22	-	2,651,114	0.75	1,988,335.41
6	Geo-net	-	92.77	1,623.00	142,216.22	-	2,651,114	0.17	450,689.36
7	Filter Fabric	-	92.77	1,623.00	142,216.22	-	2,651,114	0.18	477,200.50
8	Soil Cap	3	92.77	1,623.00	142,216.22	16,925.35	299,062	4.00	1,196,249.58
9	Revegetation	-	105.14	1,647.00	162,440.05	-	2,732,009	0.03	76,496.26
								Cover Cost	9,235,938.67

Cell Liners

Layer	Material	Thickn (ft)	Side Length (ft)	Width (ft)	Side Area (SF)	Side Volume (CY)	Total Quantity (CY or SF)	Unit Cost ($)	Layer Cost ($)
1	Filter Fabric	-	58.50	1,583.00	89,537.52	-	2,542,634	0.18	457,674.13
2	Geo-net	-	58.50	1,583.00	89,537.52	-	2,542,634	0.17	432,247.79
3	HDPE	-	58.50	1,583.00	89,537.52	-	2,542,634	0.75	1,906,975.56
4	Sand	1	58.50	1,583.00	89,537.52	3,319.45	94,185	12.00	1,130,215.60
5	Compacted Clay	3	58.50	1,589.00	89,713.03	10,810.33	285,962	8.00	2,287,694.24
-	Bottom of Clay	-	67.99	1,607.00	104,872.99	-	-		
								Liner Cost	6,214,807.33
								Fill Cost	547,876.00
								PVC Pipe	264,740.00
								Total/cell	16,263,362.00

APPENDIX V

RECOMMENDATIONS FOR CONFIRMATORY WORK

V.0 RECOMMENDATIONS FOR CONFIRMATORY WORK

V.1 GEOTECHNICAL AND GEOPHYSICAL STUDIES FOR SITE CHARACTERIZATION

This appendix describes geotechnical and geophysical studies that are recommended to better define site-specific subsurface characteristics for further development of on-site land disposal facility technology. The general information used in the site selection process for this task will need to be confirmed at each of the recommended sites and site-specific values of soil properties established for use in design.

Parameters that would need to be established or confirmed include the following:

1. Surface Topography. Mapping should include the candidate site and immediately surrounding area, with a contour interval of 2 ft and a scale of 1 in = 100 ft.

2. Groundwater Elevation. Mapping should be based on the highest elevation recorded in four seasons of data and provide a contour interval, scale, and area coverage as in No. 1 above.

3. Bedrock Elevation. Mapping should be in sufficient detail to reveal exposed sand channels in the bedrock surface.

4. Soil Properties. Soil properties to be established include:

    - Field and Laboratory Soil Classification
    - Standard Penetration Resistance
    - Gradation (particle size distribution)
    - In-Place Moisture Content
    - Field Capacity (moisture content)
    - Dry Density

- o Consolidation Curve
- o Shear Strength (internal friction angle)
- o Compressive Strength, Confined and Unconfined

5. Geotechnical Investigation. Soil sampling and testing should be performed for each soil type encountered at a site. Drill holes should be arranged based on field conditions; however, a suggested minimum spacing is one at each corner and one at the center of each planned waste cell.

6. Geophysical studies. Because the widely spaced drill holes described above cannot detect local or small scale features, such as sand channels or groundwater mounds located between them, the drilling and testing program should be supplemented by geophysical studies. Geophysical techniques should be used in conjunction with drilling and the two programs should complement each other (i.e., drill hole locations should be added or adjusted to investigate anomalies identified in the geophysical surveys).

Six geophysical techniques that may be applicable are briefly discussed below. They are listed in ascending order according to relative cost, except for Induced Polarization (IP), for which no cost has been determined.

1. Electromagnetic (EM) studies could be conducted to identify alluvial channels in the bedrock and paleochannels on the surface of the bedrock. EM techniques have been used on RMA as documented in a July 1986 report by Technos, Inc., prepared in support of Task 38. The Technos report showed that the best results were found where microgravity and EM techniques were used together. The variability in the data collected was concluded to be due to varying density of the bedrock. It is proposed that the results of an EM study could also be combined with well log data to

produce an accurate depth to bedrock survey. EM studies would be the least expensive of the five techniques listed here for which cost has been determined.

2. Microgravity studies were used in combination with EM studies on Task 38. Where the EM results were ambiguous, microgravity data were used. For example, an EM study may show a feature that could be interpreted as a paleovalley, but it would not be known if this feature was topographic in nature or whether it was a density change between clay and sand. In this situation, microgravity could be used to resolve the issue. Gravity surveys are expensive, however, because they require an accurate survey to establish ground-control points. For this reason, microgravity surveys should be used only to resolve ambiguities in EM survey data.

3. Ground Penetrating Radar (GPR) represents a relatively new technique for determining the depth to groundwater. GPR produces seasonally varying results depending on the amount of moisture in the alluvium. During the wet season, GPR would have less penetration, but during the dry season it would show a definite reflection at the groundwater level. Any subsurface definition below the groundwater level would be observed. GPR may have promise as a technique to define the extent of the alluvial versus the bedrock aquifer. It is not known whether GPR can penetrate down to an aquifer below 30 to 40 feet below the surface.

4. Seismic Refraction studies could be used to determine bedrock topography and bedrock faulting. Seismic refraction techniques produce data that are not graphic in nature and are therefore more difficult to interpret and correlate with subsurface characteristics. Refraction studies are not recommended because of this difficulty in interpreting results.

5. Seismic Reflection techniques, such as a weight drop, could be used to map sands on the top and near the top of the Denver formation. The weight drop technique shows clean results because of a high signal-to-noise ratio. The reflection technique would be the most expensive of the techniques listed and therefore would only be recommended for specific bedrock mapping objectives.

6. Induced Polarization (IP) techniques have been used recently by RMA staff for mapping sands in existing boreholes on RMA, with good results. The IP technique can also be used for surface measurements. It is suggested as a technique to complement rather than replace reflection studies.

To summarize the six geophysical study techniques described above: an EM technique is recommended for mapping subsurface conditions at the top of the bedrock and the overlying alluvium; GPR is recommended for depth-to-groundwater measurements when the groundwater level is above or slightly below bedrock surface; and finally, seismic reflection is recommended for mapping sands in contact with the bedrock surface or below the surface.

V.2 WASTE COMPATIBILITY STUDIES

In order to plan the placement of waste in the cells of a land disposal facility, it is necessary to establish which waste types may be disposed together and which must be segregated from each other to prevent chemical reaction. The adverse effects of such reactions can include explosion, fire, heat, leachate generation, and gas generation. Wastes that could produce such effects if brought into contact with each other would be segregated into different zones of a waste cell or into different cells.

Because the wastes at RMA include a wide variety of chemicals, the design of a compatibility testing program should be undertaken with the intent to select those wastes most likely to be reactive, excluding those that would be treated prior to disposal and those that are known to be nonreactive based on prior industry experience. It may be determined that treatment residues should be included in this study once the treatment processes and the types of waste to be treated are identified.

V.3 CONSTRUCTIBILITY TESTS

The facility configuration developed for this task and the operational plan presented in Appendix III are believed to reflect the state-of-the art in design and construction of such facilities. However, the materials available at RMA and the construction techniques and equipment recommended for shaping those materials into a system that will perform as required should all be tested before the start of the major construction effort that building this facility would entail.

It is usual in the preparation for construction of engineered earthwork structures to build a test fill for demonstration of the effectiveness of the materials, machinery, and techniques to be employed in the work. One element of the waste cell configuration developed for this task that should be demonstrated in a test fill is the soil barrier layer of manufactured clay, actually a bentonite - soil mixture. Both the permeability and constructibility of the soil barrier need to be demonstrated using various RMA soils and various bentonite ratios to develop an effective and economical design. The field work would take place after preparatory laboratory studies had narrowed the range of the variables and would be confirmatory in nature.

Because the waste cell is a complex system, both its construction sequence and its performance when complete are subject to improvement through testing. It is suggested that initial construction of a small capacity waste cell could be undertaken to optimize the construction method, and the completed cell subjected to testing to demonstrate its performance. The demonstration cell could be filled with inert soil materials or with simulated or actual RMA wastes, depending on the test design.

APPENDIX VI

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APPENDIX VII

LIST OF TARGET CONTAMINANTS

AT RMA

TABLE VII-1

LIST OF TARGET CONTAMINANTS AT RMA*

Analytes	Indicator ** levels (ug/g)	Waste Type
Aldrin	0.3	C/H
Arsenic	4.7/10.0	C/H
Atrazine	0.3	C/H
Azodrin		C/H
Benzene; Benzol	0.3	C/H
Benzothiazole, BTA		C/H
Bicycloheptadiene; BCH	0.3/0.4	C/H
Biscarboxymethyl sulfone [a/]		S
Biscarboxymethyl sulfoxide [a/]		S
Bromide		C/H
Cadmium	1.0/2.0	C/H
Carbon tetrachloride	0.3	C/H
Chlordane	0.6/2.0	C/H
Chloride		C/H
Chloroacetic acid [a/]		S
Chlorobenzene	0.3/1.0	C/H
Chloroform	0.3	C/H
2-chlorovinyl arsenic acid [b/]		S
2-chlorovinyl arsenous acid [b/]		S
p-Chlorophenyl methyl sulfide; CPMS	0.9/4.0	C/H
p-Chlorophenyl methyl sulfone; CPMSO	0.3/0.6	C/H
p-Chlorophenyl methyl sulfoxide; $CMPSO_2$	0.3/7.0	C/H
Chromium	25/40	C/H
Copper	20/30	C/H
DDE	0.3/0.6	C/H
DDT	0.5/0.6	C/H
1,2-Dibromo-3-chloropropane; DBCP; Nemagon	0.005/0.3014	C/H
1,1-Dichloroethane	0.9/2.0	C/H
1,2-Dichloroethane	0.3/0.6	C/H

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TABLE VII-1 (Continued)

LIST OF TARGET CONTAMINANTS AT RMA*

Analytes	Indicator ** levels (ug/g)	Waste Type
1,1-Dichloroethylene		C/H
1,2-Dichloroethylene	0.3/2.0	C/H
Dicyclopentadiene; DCPD	0.4/1.0	C/H
Dieldrin	0.3	C/H
2-(Diisopropylamino)-n-ethyl sulfonate[e/]		S
2-(Diisopropylamino)-n-ethanethiol[e/]		S
Diisopropylmethylphosphonate; DIMP	0.3/1.0	S
Dimethyl disulfide; DMDS	0.8/20.0	C/H
Dimethyl methyl phosphonate; DMMP	--	S
Dimethyl arsenic acid [b/]		S
Dimethyl mercury [b/]		S
Dithiane	0.4/7.0	S
Endrin	0.3/0.5	C/H
Ethyl benzene	0.3/0.4	C/H
Ethyl methyl phosphonate (EMP)[e/]		S
Ethyl methyl phosphonic acid (EMPA)[a/]		S
Fluoride[d/]		S
Fluoroacetic acid[d/]		S
GB; Sarin		S
Hexachlorocyclopentadiene; HCCPD	0.3/0.6	C/H
Isodrin	0.3	C/H
Isopropyl methyl phosphonic acid[d/]		S
Isopropyl methyl phosphonate (IMP)[d/]		S
Lead	25/40	C/H
Lewisite		S
Lewisite oxide		S
Malathion	0.3/0.7	C/H
Mercury	0.05/0.1	C/H
Methylene chloride	0.7/2.0	C/H
Methyl arsenic acid[b/]		S

TABLE VII-1 (Continued)

LIST OF TARGET CONTAMINANTS AT RMA*

Analytes	Indicator ** levels (ug/g)	Waste Type
Methyl isobutyl ketone	0.3/0.7	C/H
Methyl mercury salts[b/]		S
Methylphosphonic acid		S
Mustard		S
N-Nitrosodimethylamine[c/]		C/H
Parathion	0.4/0.9	C/H
Supona	0.3/0.6	C/H
Tetrachloroethylene	0.3	C/H
Thiodiglycol[a/]		S
2,2-thiodiglycolic acid[a/]		S
Thioxane; 1,4-Oxathiane	0.3/6.0	S
Toluene	0.3	C/H
1,1,1-Trichloroethane	0.3/0.4	C/H
1,1,2-Trichloroethane	0.3/0.4	C/H
Trichloroethylene; TCE	0.5	C/H
Trimethyl phosphate		C/H
Vapona	0.3/3.0	C/H
o,m,p-Xylene	0.3/5.0	C/H
Zinc	60/80	C/H

a/ Degradation product of mustard.
b/ Degradation product of lewisite.
c/ Degradation product of hydrazine
d/ Degradation product of GB.
e/ Degradation product of VX.

* This is a preliminary list of target contaminants for RMA Task 35 as of December, 1986.

** Indicator levels are given only where USATHAMA certified methods and reporting limits have been established.

Legend: C/H = Chemical/Hazardous; UXO = Unexploded Ordnance;
S = Surety

APPENDIX VIII

COMMENTS AND RESPONSES

0021w
09/15/88

Shell Oil Company

c/o Holme Roberts & Owen
Suite 1800
1700 Broadway
Denver, CO 80290

October 20, 1987

FEDERAL EXPRESS

Mr. Donald L. Campbell
Department of the Army
Office of the Program Manager
Rocky Mountain Arsenal
Contamination Cleanup
ATTN: AMXRM-EE
Bldg. 4460
Aberdeen Proving Ground, MD 21010-5401

Re: United States v. Shell Oil

Dear Don:

Enclosed herewith are Shell Oil's comments on the Draft Final Report on Task No. 27 - Hazardous Waste Land Disposal Facility Assessment.

Sincerely,

C.K. Hahn

C. K. Hahn
Manager
Denver Site Project

CKH/mp/14222

Enclosure

cc: (w/enclosure)
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RESPONSES TO COMMENTS OF
SHELL OIL COMPANY ON
TASK 27, HAZARDOUS WASTE
LAND DISPOSAL FACILITY ASSESSMENT

Comment 1: Page 1-1, third paragraph, first bullet: A statement should be included identifying the assumption that was made concerning the volume of waste that might be a candidate for disposal in the facility. It is inappropriate to lead the reader to assume that all potentially identified contaminated soils will be disposed of in the subject landfill. The volume used by the Army is an extremely conservative estimate of a potential upper bound on the size of the landfill.

Response: The comment appears to address the first sentence of Section 1-1 and the first and second bullets of Section 1.3, rather than the cited first bullet of Section 1.2.

These sections have been revised to further identify the assumptions on which the volume estimate is based. There is nothing inappropriate in these assumptions; the volume estimate is meant to provide an upper bound for the site cleanup need for landfill capacity.

For this purpose, the estimate must be conservative. No one can say whether it is "extremely conservative," as the commentor claims, until the outcome of the "How Clean is Clean?" effort and decisions regarding land use and groundwater cleanup. Therefore, the assumption used in this assessment that detection limits for organics define action levels is an appropriately conservative approach.

Comment 2: Page 1-2, top of page, last bullet: Preparing a report describing the waste sources appears to be an unnecessary effort in the context of this task. It is premature to assemble this information for inclusion in the report because screening of treatment technologies has not taken place. It is, therefore, premature to presume all wastes will be disposed in the landfill.

Response: We disagree from a waste management perspective and from a land disposal facility siting perspective. Land disposal facility feasibility studies can be very site-specific and waste-handling dependent. It is not inappropriate to make a best engineering judgment estimate of the maximum waste volumes (i.e., primarily contaminated soil) and waste sources with their location and potential soil type, in order to establish the upper-bound facility capacity.

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Comment 3: Page 1-3, top of page, second line: Insert "which may be" between "processes" and "required". A treatment has not been selected, therefore, it is premature as stated.

Responses: We agree with the comment and have made the change.

Comment 4: Page 1-3, first bullet: Liquid wastes could be disposed of at such a facility if a solidification-type pretreatment were utilized.

Response: The statement on page 1-4 simply reflects the liquid waste disposal prohibition. We agree that a solidified waste is not a liquid waste. No change to the text is required.

Comment 5: Page 1-4, fourth paragraph: Has a cost estimate been made which demonstrates that it is more effective to create a manufactured clay for the waste cell than to import all new clay?

Response: No. The manufactured clay will probably be more expensive than local imported clay. The choice for this assessment was made on the basis of assured quality of the product, given that local natural clays on or off the RMA do not appear to be of sufficiently low permeability. Since the manufactured clay is more costly, the conservatism of the estimate of this item is ensured.

Comment 6: Page 3-4, first line: The 50-year average annual precipitation at Stapleton is 15.31 inches, not the reported 14 inches (National Climatic Data Center, 1985).

Response: The reported 14 inches average annual precipitation was obtained from a climatic atlas isohyetal map and from the Soil Survey of Adams County. The value in the text has been changed to 15 inches. The change does not affect the discussion.

Comment 7: Page 3-4, second paragraph: It is the opinion of Shell and Morrison-Knudsen Engineers (MKE) that significant deep percolation does occur over vegetated soils on the RMA. As an example, calculations have indicated an average annual deep percolation of 0.78 inches over a 10-year period for a vegetated, 36-inch layer of Blakeland Loamy Sand. Less sandy soils allowed less deep percolation. It is an oversimplification to conclude that "free soil moisture does not normally penetrate much below 12 inches" in medium to moderately fine textured soils due to the presence of calcium horizons.

Response: Significance depends on the subject under consideration. The term "significant" can be interpreted in relation to groundwater hydrology, in relation to waste cell performance, or in relation to contaminant migration from specific contaminated sites on RMA.

"Significant" deep percolation, as it relates to groundwater hydrology, implies an amount sufficient to recharge the aquifer or to supply wells. The amount of recharge calculated by the commentor would support only one 750 gpm well for the entire area of RMA, which hardly seems "significant" compared to the water requirements of irrigated crops if they covered the same area; it would not even supply the actual water consumption of Commerce City, immediately downslope on the aquifer.

"Significant" deep percolation, as it relates to waste cell performance, would be a much greater amount than the .78 inch the commentor has calculated; in Figure 5-10, HELP model results for percolation through a 24-inch vegetated soil layer are shown as 1/2 inch per year. That amount is not "significant" in the sense of being an obstacle to a demonstration of successful waste cell performance, although it is an overestimate of the expected percolation, based on a conservative application of the model.

There is no Blakeland loamy sand at the locations studied for the disposal facility, which are Ascalon, Platner and Truckton soils. These are less sandy and more fine textured than Blakeland and include calcium horizons, which according to the commentor means they allow "less deep penetration, much below 12 inches in medium to fine textured soils due to the presence of calcium horizons." This is a fair statement of the position taken in the discussions presented in this part of the assessment and contradicts the commentor's opinion that "significant deep percolation does occur." However, the detailed public health implications basis for this assessment is the HELP model that, when conservatively applied, predicts a small amount of deep percolation as discussed above.

That some deep percolation does occur is evidenced by the vertical migration of contaminant plumes in the unsaturated soil zone from some contaminated sites on RMA. The context of the sources' observations about soil moisture and deep percolation did not encompass contaminant plumes. If there were no deep percolation whatever, the plumes would not migrate toward the water table and the number of RMA waste sites requiring remediation might be reduced. In this sense, any deep percolation at all is "significant;" however, that is not the context of the regional discussion on Page 3-4, which is directed toward an assessment of the suitability of the area for a waste disposal facility.

No change to the text is required.

Comment 8: Page 3-7, third paragraph (also page 3-10, second paragraph): The statement is made that faults were not mapped as site selection criteria because of the lack of accurate maps. We believe that the faulting issue at RMA has not been properly addressed. Several maps have been produced by Army contractors locating faults in the Basin A-Neck area based on lithologic logs. We believe that the lithologic data does not necessarily indicate such faulting.

Response: The faults inferred by various investigators from well log data may or may not exist, and the investigations required to establish this have not been performed. However, the inferred faults lack surface expression and have no identified association with the recent seismicity of the area, so that there is no presently known evidence of near-surface holocene fault movement on RMA. There is a consensus that no faulting has occurred in Holocene time.

Therefore, maps of inferred faults in the Denver Formation do not affect selection of facility locations for the purposes of this Assessment, which is based strictly on available information.

A more detailed examination of any postulated faulting affecting particular candidate sites would be appropriate to support further development of the waste disposal alternative should a decision to proceed beyond this assessment result from the CERCLA process, in the event that other investigations had not resolved the matter by that time.

No change to the text is required.

Comment 9: Page 3-7, last complete sentence: The RMA injection well was 12,045 feet in depth.

Response: This information has been incorporated in the text.

Comment 10: Page 3-10, first paragraph: There are several qualifying words used in the sentence. The conclusion, while firm, is based on these qualified statements. For example, "the geophysical surveys conducted during the 1960s suggest that it does not expand into the sedimentary rocks overlying the linear zone of earthquakes" doesn't make a solid case for the final statement that the fault is more than 1,000 feet from the surface.

Response: Geologists, as scientific professionals, nearly always qualify their opinions for the good reason that further investigation may prove them wrong. Decisions based on their qualified opinions, however, have of necessity a more absolute "go" or "no go" quality. In this case, the assessment finding is that no siting restriction on account of the Derby Fault has been identified by the geologists who have studied it. This firm statement is fully and sufficiently supported by the qualified statements made by the sources.

No change to the text is required.

Comment 11: Page 3-10, second and third paragraphs: The discussion on faulting in the Basin A area is not supported by the interpretation of the available data.

Response: It is assumed that "the discussion" referred to is that of May et al. (1983), and that "the interpretation" referred to is that of others who are not identified in the comment.

Further work has been performed by other parties, including Ebasco, in the Basin A area since that described by May et al. (1983). A paper co-authored by Ebasco's L. Irons (Crowder et al., 1987) provides a description of some of that work. The more recent work does not alter the significance of the overlying Pleistocene lacustrine and alluvial deposits in indicating an early Pleistocene (at the latest) date for Basin A inferred faults. Therefore, these features (whatever their interpretation) do not represent a siting restriction, as stated in the fourth paragraph of page 3-10.

No change to the text is required.

Comment 12: Page 3-11, first complete sentence: There is no geologic evidence of faulting in the Basin F area. It is speculative to postulate their existence on the basis of a creative interpretation of limited data in the Basin A area.

Response: We agree. The sentence has been deleted from the text.

Comment 13: Page 3-12, second paragraph: Refer to comment number 38 for a discussion on travel time calculations. Relying on the unsaturated zone to secure 1,000 years of isolation is not a conservative design approach.

Response: An effort has been made in this assessment to emphasize natural as opposed to man-made barriers to contaminant migration in accordance with EPA guidance.

Recalculation of the travel time using the EPA guidance manual method as recommended by commentor at 38(b) gives a minimum travel time in the unsaturated zone of 1,514 years, compared with 726 years calculated time to reach field capacity, which indicates the conservatism of travel time calculations made by that method. A complete comparison is provided in revised Table 5-6.

Comment 14: Page 3-15, first paragraph, last sentence: If the decision were made to decommission the North Plants, would it then be possible to expand the area under consideration for a landfill facility?

Response: The potential difficulty and complexity of North Plants decontamination and site cleanup was the basis for an exclusion criterion to our landfill siting work. The criterion was to exclude such contaminated sites as North Plants, South Plants, Basin F, and Basin A (See Figure 3-4).

Comment 15: Page 3-15, last paragraph: The volume estimate is not based upon the best available information, but rather on an old estimate with the detection limits employed at that time. This is only a convenient figure considering that no action levels have been established nor have technologies been selected for treatment options.

Response: The estimate reflects the best engineering judgment for the maximum required facility capacity made at the time the assessment was prepared, as demonstrated in Appendix I, Table A-2. The text has been changed to reflect this.

Comment 16: Page 3-17, Table 3-2, last item: Calculating a volume-distance weighted centroid using the current volume estimates will necessarily result in misleading conclusions. The calculation will change substantially once action levels are set and alternative treatment technologies are brought to bear. Such a calculation is meaningless this early in the RI/FS process.

Response: The volume-distance weighted waste centroid is a common feasibility study tool for estimating potential differences in transport costs between waste management facilities. Distance from the waste centroid is a reasonable criterion for siting landfill or other waste management facilities. Also, whatever action levels are set, the location of the contaminated sites will not change and the centroid will be close to the position calculated in this Assessment.

Comment 17: Figure 3-5: Our interpretation of the available data indicates that saturated alluvium exists in a bedrock channel exiting the Basin A area in a northwesterly direction. No such continuous "A-Neck" is indicated on the figure.

Response: The "A-Neck" is a small feature within a larger surrounding region of saturated alluvium displayed on Figure 3-5. For this assessment, no purpose would be served in specifically identifying such a local feature, continuous or not. The second paragraph of the unsaturated alluvium criterion discussion on page 3-14 and the sand channels discussion on page 3-21 place these subjects in context for this assessment.

No change to the text is required.

Comment 18: Page 3-50, entire page: Significant recharge in the form of deep percolation from vegetated areas can occur over the RMA. The discussion on this page oversimplifies this issue. Specific comments are as follows:

- To discount the HELP model results on the basis of the Resource Consultants Inc. (RCI) 1982 report is improper. The RCI use of the Blaney-Criddle method was a monthly water balance approach that could not take into account the day-to-day or moment-by-moment fluctuations in rainfall, solar radiation, etc. Using such a crude time-step masks the deep percolation predicted by the more refined HELP model daily calculation approach. The HELP model results have been confirmed by an in-house modeling effort which uses time steps as small as 5-minutes during precipitation events.

- Another problem with the RCI approach is that the winter season was not considered. Only the months from April to October were analyzed. This does not account for the potential percolation during the wet spring season when the ground can be relatively warm with multiple wet snowfalls.

- Fourth paragraph: It is obvious that the averaging that occurs using a monthly water balance approach will not pick up the effects of individual major storms. Therefore, it should not be surprising that monthly consumptive water use calculations would not demonstrate the deep percolation one would expect to see associated with storms.

Response: The statement that "significant recharge in the form of deep percolation from vegetated areas can occur" contradicts the conclusions of previous workers at RMA and the HELP model results obtained in this assessment. The HELP model results show a small amount of deep percolation occurs; the only sense in which it is "significant" is that it can move contaminant plumes downward toward the water table from contaminated sites on RMA. This is not "recharge" in the customary sense.

The discussion on page 3-50 does not "oversimplify this issue," rather, it refutes the commentor's opening statement by reference to the conclusions of previous workers and presentation of the results of the HELP model calculations performed in this assessment. The first paragraph of page 3-50 refers to "slow rate of migration of leachate" from a properly designed disposal facility, not from contaminated soils sites; the text has been expanded to clarify the intention.

The first specific comment states that it is improper to discount the HELP model results on the basis of the Blaney-Criddle method owing to the monthly time step used in the latter versus the daily time step in the HELP model. The intent of the discussion on page 3-50 was to establish the conservatism of the HELP model, which, far from being "discounted," was used as the basis for development of waste cell configuration in Chapter 5.

The time step objection would become meaningful only under wet conditions not usually found at RMA with its large available water capacity of the soil; as long as there is available water capacity, the time step is of interest only in predicting runoff versus soil infiltration, for which case the Blaney-Criddle method errs on the conservative side by ignoring runoff.

In the same RCI work, the average runoff from RMA, adjusted from RCI Table 4 to account for vegetated areas only, is .5 in/year; the HELP model gives .1 in/year, or about one-fifth the run-off calculated by RCI, another indication of the conservatism of the HELP model (Report Section 5.4.3, item 1 on page 5-35).

The second specific comment states that the Blaney-Criddle method does not account for the potential percolation during the wet spring season prior to April. Again, this comment may have some application to climates which experience wet spring seasons, however, at RMA there is virtually no effective (i.e., greater than 0.1 inch in a single storm) precipitation prior to April. That portion of rainfall and snowmelt that does not escape as evaporation and runoff enters the soil and recharges the top 12 inches depleted of moisture in the previous year's growing season, as described in the Soil Survey of Adams County. No problem with the approach exists on account of the winter or "wet spring" seasons, which are appreciated in the sources and in the discussion derived from them.

The third specific comment states that "the averaging that occurs using a monthly water balance approach will not pick up the effects of individual major storms." One effect of individual major storms is to create runoff, since the effective rate of percolation of surface water into the soil is less than the precipitation rate at the peak intensity of such storms. Far from failing to "demonstrate the deep percolation one would expect," the error is on the conservative side so long as the available water capacity of the soil has not been used up, since the runoff lost is not acknowledged by the method.

No change to the text is required.

<u>Comment 19</u>: <u>Page 3-51, last sentence</u>: This sentence overstates the case. Over an extended time, percolation will penetrate the cap and reach the waste.

<u>Response</u>: The sentence overstates the case in that no time limit was given. The sentence has been revised.

Comment 20: Page 4-11, last time in list: Using the HELP model's default climatological data (1974-1978) is inappropriate. These years were below-average in precipitation (12.99 inches vs. 15.31 inches for the 50 years through 1985). A more appropriate approach would be to employ the HELP model's ability to accept 20 years of user-defined climatological data. The wettest consecutive 20 years from 1949 to 1983 were 1955 through 1974, with an annual average precipitation of 15.98 inches and a peak daily precipitation of 3.27 inches. (The peak daily precipitation of the HELP default data is only 1.79 inches.) Using such relatively lower precipitation values will result in overpredicting landfill performance.

Response: For the purpose of this assessment the default data are considered sufficient to identify the best waste cell cover and liner configuration. The example demonstration of the protective life of the facility has been revised using 20 years of daily precipitation data from 1963 to 1982, for which period the average annual rainfall was a more representative 15.13 inches (16-1/2 percent more than the 12.99 inches in the 1974-1978 HELP Model default data set). The calculated percolation rate from the base of the waste cell cover increased by only 4 percent, which indicates that there is a relatively small sensitivity of waste cell performance to minor variations in precipitation. The revision does not alter the conclusions of the assessment. More extensive climatological data would be used for further development of the concept.

The text has been changed (Section 5.4.2, page 5-28 and Section 5.4.3, page 5-32) to reflect the results of the expanded analysis, which has also been revised to incorporate more complete soil and vegetation information than were used in the draft.

Comment 21: Page 5-3, item (a): What are considered "acceptable levels" for soil loss in this conceptual design? Sufficient data stating what USLE parameters were chosen should be provided to reviewers to allow them to conduct a meaningful review.

Response: The acceptable levels utilized for this assessment are in substantive conformance with RCRA, i.e., erosion of less than 2 ton/acre.

Comment 22: Page 5-3, third paragraph: We disagree with the statements regarding precipitation at RMA. The following table of data is from 50 years of record through 1985 (Source: NCDC, 1985. All values in inches).

Year	J	F	M	A	M	J	J	A	S	O	N	D
15.31	0.51	0.69	1.21	1.81	2.47	1.58	1.93	1.53	1.23	0.98	0.82	0.55

Also, using terms such as "leachate runoff" confuses the water balance issue.

Response: The text has been changed to reflect 15 rather than 14 inches of rainfall a year. The changes do not alter the conclusions of the discussion. It is necessary to use the phrase "leachate runoff" in this context; the "soil water balance" has nothing to do with the subject under discussion on page 5-3, which is concerned only with surface water management.

Comment 23: Page 5-10, Figure 5-5: What are the assumptions for this figure (e.g., waste volume, height, etc.)? What do the different curves represent? The text is not clear.

Response: The commentor appears to mean "parameters" rather than "assumptions."

The text and figure have been changed to identify that the curves are for different cell side lengths, which was inadvertently omitted.

Comment 24: Page 5-11, fourth paragraph, first sentence: A review of Figure 5-6 indicates that the A Concept costs are closer to the B Concept than to the C Concept.

Response: This comment appears to refer to the last sentence rather than the first. The text has been revised.

Comment 25: Page 5-11, fifth paragraph, last sentence: Figure 5-6 indicates that the B and A concepts are closer in cost than are the B and C concepts.

Response: We agree. The text has been revised.

Comment 26: Page 5-16 and following, paragraph 5.3.3: The text does not recognize that certain types of wastes can impact a bentonite amended soil liner. Other soil liner systems are rejected due to a lack of information, yet a bentonite amended soil liner is chosen without a similar discussion.

Response: It is fully realized that a bentonite amended soil liner may be susceptible to attack. It is beyond the scope of this assessment to evaluate liner/leachate compatibility for actual disposed concentrations of all the possible specific wastes at RMA, which, by regulatory requirement, is done on a case-by-case basis during facility operation. The bentonite liner was selected based on engineering judgment considering the uncertain availability of suitable clay at or near the RMA and the general character of the material likely to be disposed. Since bentonite amended soil is more expensive, the choice is the conservative one.

Comment 27: Page 5-17, second paragraph, second sentence: The referenced report (Martin, 1986) appears to be an internal Ebasco document. Please produce this report to the MOA parties.

Response: This report has been delivered to the MOA parties.

Comment 28: Section 5.4.1 (pages 5-20 through 5-28): This section discusses the selection and configuration of various landfill cover components by using the HELP computer program water balance simulation. It is not possible to review this section in detail without the actual computer output. The HELP model requires much climatological, soil, vegetative and dimensional data, any of which have a significant impact on calculated percolation rates. Input data must be reviewed for reasonableness and consistency. Also, a discussion of the assumptions underlying the HELP code is in order before conclusions are arrived at prematurely.

Response: Although actual data entries are not listed in the HELP model format, the values of the input parameters are already discussed in the text in more than usual detail for a report of this type. It would be inappropriate to incorporate voluminous technical calculations in the assessment.

HELP files have been transmitted to the commentor as a courtesy.

Comment 29: Page 5-23, Table 5-2: The cover system shown in Table 5-2 should be analyzed using the 20 years of Denver precipitation data from 1955 through 1974. The 5 years of default precipitation data used in the HELP code were unusually dry years. (See comment 11 above.)

Response: Commentor apparently means to refer to his Comment 20, not Comment 11, which deals with faulting in Basin A rather than rainfall.

The five years of default data supplied with the HELP model were used, together with other available information, to guide selection of the best waste cell configuration in a feasibility level technology assessment, for which use the default data are adequate. A revised public health implications sensitivity analysis has been performed, as described in the response to Comment 20, which confirms that use of 20 years of representative rainfall data does not alter the conclusions of this assessment.

In any further development of this technology for application at RMA, a more precise deep percolation value would be obtained by using more complete climatological data, together with more precise and site-specific topographical, groundwater, soils, and vegetation information than were available for this assessment.

Comment 30: Page 5-23, Table 5-2:

(a) What values for the following parameters were used to generate this table:

- Evaporation depths(s) (a critical parameter)
- Vegetative cover type/condition
- Porosity, field capacity, wilting point and effective hydraulic conductivity of the various materials
- Runoff curve number(s)

(b) Was any attempt made to match soil parameters with actual RMA soils?

(c) Table 5-2 is used as the basis to conclude that negligible benefit is derived from increasing the vegetative soil layer thickness. This conclusion is premature and depends on the soil wilting point, porosity and the assumed evaporative depth(s).

Response: Values of the parameters used in the various computer runs are too voluminous to repeat here. They are available in the HELP model files, which have been transmitted to the commentor. The values are those given or recommended by the sources cited in the text.

As stated on Page 5-35, first paragraph, which the commentor has recognized at the end of Comment 37, soil data (unit weight, moisture content, and porosity) were obtained from soil investigation reports available in the Shell database. The values selected for use in the assessment represent a composite of RMA soil types rather than a particular soil at a particular spot. They are also similar to the values of those parameters used in other geological evaluations at RMA.

We disagree that the conclusion is premature, although it certainly does depend on the named parameters (called "assumptions"). The assumption used in the assessment was that the vegetation that would establish and maintain itself with a minimum of human intervention was native prairie grass; the values of the parameters were determined from the Soil Survey of Adams County and the HELP model user's guide for this vegetation. The conclusion is valid for the range of depths and the vegetation type used, even though the evaporative zone depth has been increased in accordance with further guidance from the author of the HELP model for the facility protective life estimate.

Comment 31: Page 5-24, top paragraph: The argument is presented that a three foot clay barrier is preferred over a two foot barrier. It is also stated that increasing the thickness from two to three feet reduces percolation by 0.002 inches per year. (This is equivalent to a 0.4 percent reduction.) On page 5-22, third paragraph, a 3 percent change in percolation rates is considered "a small gain in efficiency" that cannot be used to justify the increased cost of an additional drainage layer. This inconsistent reasoning should not be used to support a premature commitment to three foot thick clay barriers.

Response: The EPA Guidance Document for a double-lined facility recommends a three-foot clay barrier from a construction quality assurance standpoint. This assessment follows the Guidance Document's recommendation, as clearly stated on page 5-24.

Comment 32: Page 5-24, third paragraph, last sentence: A hydraulic conductivity of 1,500 in/hr is two orders of magnitude higher than a GS soil as listed in the HELP manual in Table 2 (p. 15). Also, EPA guidance specifies 10^{-2} cm/sec (14 inc/hr) as a minimum. 1,500 in/hr seems excessive and will exaggerate the calculated cap performance. Therefore, Case 1 on Table 5-3 is more reasonable.

Response: The drainage layer is not a "GS Soil" and, therefore, the default soil properties for that soil provided in the HELP model in Table 2 were not used. The goal of the modeling was to design the most efficient liner and cover system. A clean gravel layer has a hydraulic conductivity between 5,000 and 50,000 in/hr (U.S. Dept. of the Interior Groundwater Manual, page 28). It is therefore reasonable to assume that a drain layer can be designed to have a hydraulic conductivity of 1,500 in/hr.

Comment 33: Page 5-27, fourth paragraph, first sentence: Depending on soil type and rooting depth, the thickness of the uppermost soil layer in the cover profile can have a significant effect on deep percolation.

Response: This appears to be a derivative of Comment 30(c). The statement is true, but inapplicable. Since soil type and rooting depth are defined, as described in the response to Comment 30(c), the thickness of the uppermost soil layer has no significant effect on deep percolation.

Comment 34: Page 5-28, last sentence: The HELP model is sensitive to runoff curve number selection. An artificially low value should be used to eliminate runoff and consequently enhance infiltration, thereby resulting in a conservative estimate of landfill cover performance.

Response: The HELP model is relatively insensitive to modest changes in curve number. This was verified by a HELP run varying the curve number from the default of 84.4 to a value of 71. We disagree that runoff should be eliminated through use of an artificially low value on the grounds that such an approach is unnecessary where the landform is controlled. It may have application in the case of municipal sanitary landfills, where control of landforms to maintain drainage is made difficult by large differential settlements in the organic waste; however, the RMA waste is predominantly in the form of contaminated soil and the waste zone would be constructed as an engineered fill, minimizing subsequent settlement and allowing a high degree of confidence that drainage slopes would be permanent.

Comment 35: Page 5-31, Table 5-5:

(a) The interpretation of this table is difficult without additional details on the input data used to generate the results. It is assumed that the results are based on the 5 years of climatological data from 1974 to 1978. The table indicates that the water percolating through the cap displaces an equivalent volume out of the waste zone and into lateral drainage and vertical percolation out of the landfill bottom. It must be recognized that the HELP model is conservative in that it sets the initial moisture content of the waste zone at field capacity. This results in the release of leachate out of the waste zone as soon as the first drop enters the waste from the cover system. In reality, proper construction methods combined with the semi-arid Denver climate will result in the waste zone having a significant storage capacity prior to reaching field capacity.

(b) As stated in previous comments, for conservatism, the HELP model should be run with 20 years of "wetter" climatological data and an artificially low curve number to enhance infiltration.

Response: The table input data corresponds to the waste cell cross-section shown in Figures 5-8 and 5-9 and the default climatological data of the HELP model.

We understood the nature of the HELP model described by the commentor and, therefore, constructed the time history of waste cell performance shown in Figure 5-11 to reflect a realistic appreciation of the waste zone storage capacity.

As stated in previous responses, a facility protective life study using 20 years of representative rainfall data has been performed. A more complete climatological record would be used in any further development of this technology for application at RMA; however, we do not endorse manipulating either rainfall data or curve numbers to achieve unrealistically conservative results. The approach taken is sufficiently conservative.

Comment 36: Page 5-32, second paragraph, fourth sentence: The design life of a synthetic liner is typically assumed to be through the 30 year post-closure period.

Response: HDPE is an extremely inert material. It has a design life in a sheltered environment theoretically approaching infinity. Nevertheless, the typical design assumption that it starts to fail as soon as active monitoring and maintenance ceases has merit. For ease of calculation, we have not attempted to model progressive liner deterioration using repeated HELP model runs, but have simplified the liner performance history into two stages: an initial leak-tight period followed by a complete 100 percent failure.

In the event this technology were to be chosen for further development, a more sophisticated treatment of the performance history of the HDPE liners would doubtless be undertaken, since the HELP model offers the tools to support it.

Comment 37: Page 5-33, Figure 5-10: This figure reflects the unusually dry 5-years of HELP default precipitation data (12.99 inches). The 0.13 inches of runoff should be eliminated by setting the curve number at 50.

Response: Figure 5-10 has been revised based on more representative rainfall data. We do not agree that runoff should be eliminated; see our response to Comment 34.

Comment 38: Page 5-34, Table 5-6:

(a) Again, it is difficult to interpret this table without the details on the input data used by the HELP model. The last sentence on page 5-32 that continues on page 5-35 states that the moisture content and porosity of the foundation soils was taken from unspecified Shell documents. The reference (Shell, undated) is not sufficient to locate this information. The characteristics of the foundation soils are obviously critical inputs to the total travel time calculation since 827 years out of 945 (88 percent) are expended traveling through the unsaturated zone. Date taken from Shell's South Plants foundation reports (page 5-35) may not represent Shell's typical RMA conditions.

(b) What analytical method(s) were used to calculate the travel time on this table? What assumptions are inherent with the method(s)? It appears that the table reflects the following assumptions:

o Clay barriers are at 40 percent moisture. This appears high.

o The waste layer is at 23.8 percent moisture. This appears high.

o "Travel time" is equivalent to the time that the calculated flux rate takes to fill the storage capacity volume between field capacity and in situ moisture content. This is an oversimplification of a complex phenomenon, and is more appropriately called a "fill-up" time instead of a "travel time". The calculations should be executed using unsaturated flow equations.. Methods for such an analysis are provided in the July, 1986 EPA Guidance Manual on the determination of time of travel and "vulnerable hydrogeology".

(c) Even with the above assumptions, some of the values in Table 5-6 appear to be in error. The 0.0238 value under the "In Situ" column should be 0.238. The 0.98 value under the "Storage Capacity" column should be 0.018. The 0.108 value under the "Soil Storage" column should be 1.8.

Response: The table in question (5-6) is partly a table of HELP model input and output data as well as a summary of travel time calculations.

There is a detailed reference to 13 specific sources in the Shell database for RMA given by microfilm number in the citation (Shell, undated). These data, while they mostly represent the South Plants area, are the only documents carrying the relevant information revealed in a key-word search of the Army's Shell RMA database; their values of soil parameters lie in the expected range considering the locations, depths, and soil classifications, and compatible regional information. It is better to mention these data than to omit them, as they are the geographically nearest reports on the parameters of interest in facility performance evaluation. The documents have been provided to the commentor as a courtesy.

Table 5-6 has been revised to reflect further studies, so the particular numbers cited in the comment are no longer found.

The method involves calculating the time required ("fill-up time," as the commentor states) for the layer under consideration to reach field capacity at the rate of percolation from the layer above illustrated in Figure 5-10. The table has been revised to also incorporate results obtained using the methodology recommended by the commentor.

We agree that the initial moisture contents were deliberately set high to achieve a reasonable level of conservatism. The RMA soils investigations found in the Shell database are predominantly located at South Plants where the groundwater table is very high. The samples chosen were those above the groundwater table, whenever groundwater levels were identified; however, they were all very close to groundwater and accordingly are believed to be wetter than would be typical for soils averaging much further from the water table in Sections 25 or 29 where the facility would be located.

The corrections to Table 5-6 have been made, together with adjustments to incorporate more of the Shell database, soils data, and the additional analyses described in the Response to Comment 37b.

Comment 39: Page 5-35, item 2: There is insufficient data in the industry to conclude that synthetic liners begin to degrade slowly after 100 years.

Response: The statement on the liner life has been revised.

Comment 40: Pages 7-2, 7-3; Figures 7-1, 7-2: These figures are somewhat misleading in that one of the four curves is based on a 60 foot waste height. Another set of curves based on varying waste heights would be useful.

Response: The requested curves are provided in Figure 5-5, discussed on pages 5-8 and 6-5.

No change to the text is required.

Comment 41: Pages 7-6 to 7-7, Section 7.4: This discussion on the economic analysis is surprisingly brief in light of the multitude of options considered (e.g., cell size, waste height, build out period). The following specific comments apply to this section:

o Page 7-6, second paragraph: This paragraph is confusing when compared to the curves in Figures 7-1 and 7-2. The 3,000,000 CY cell layout is more expensive than the 1,500,000 CY layout, but this no doubt due to the different waste heights and is therefore a misleading comparison. The last sentence states that there is only a "small cost differential" between the 1,000,000 CY cell (at 35 feet) and the 1,500,000 CY cell (at 60 feet). The curves do not support this statement.

Response: The intent of this section is to summarize the general effects of varying key parameters rather than to recommend or justify one particular choice of size, height, or buildout period. Should this technology be selected for further development under the CERCLA process, choices would be made during the design effort based on better knowledge of volumes of waste to be disposed, buildout period, exact site size and location, and a more detailed economic analysis.

The cost estimate is printed in full in Volume II, Appendix IV, for the use of those who may wish to perform a more detailed economic analysis.

With respect to the specific comments on the curves in Figures 7-1 and 7-2, possibly the commentor is judging the relative costs based on the appearance of the figures without taking into account that the ordinate axes are not zero; for this reason, the "spread" between the curves is much less than appears at a casual glance.

No change to the text is required.

Comment 42: Page I-15, first paragraph: Contaminant toxicities and the endangerment assessment will obviously result in a different volume of "heavily contaminated soil" requiring treatment than the approach taken here.

Response: The differences in "heavily contaminated soil" will be determined based on contaminant concentration in the waste, toxicities, risk assessment, and exposure pathway modeling (i.e. endangerment assessment). The feasibility study waste volume estimates reflect the best engineering judgment made at the time of the estimate on the maximum potential site cleanup waste volume. The modular design of the land disposal facility would allow for construction of a facility of any size up to the maximum size evaluated, i.e. 16,000,000 cubic yards.

Comment 43: Page V-2, item 4: There is a reference to the relative value of seismic refraction versus other methods used in Task 38. Shell would appreciate being informed of the method(s) employed and the results obtained as this is not reported in Task 38. Preliminary results of a Shell investigation indicated that shallow seismic refraction techniques would be successful in spotting offsets as small as 10-15 feet.

Response: The commentor is correct. The information is contained in a report of Technos, Inc. (Technos, 1986), which was not incorporated in the Task 38 final report. The text has been changed.

The desired accuracy of a depth-to-bedrock survey for the final establishment of a disposal facility site is 2 to 3 feet, not 10 to 15 feet. For this reason, the seismic refraction method is not recommended.

No change to the text is required.

RESPONSES TO COMMENTS OF
EPA DRAFT FINAL REPORT
HAZARDOUS WASTE LAND DISPOSAL FACILITY ASSESSMENT

General Comment: The report is a very comprehensive assessment and clearly acknowledges that it is not a Feasibility Study per the requirements of CERCLA. The land disposal facility is simply one alternative to be evaluated in the Feasibility Study context which will include a broad screening of remedial alternatives. Because it is not a Feasibility Study, the report does not address threats to public health and the environment, alternate treatment technologies, and the fact that the land disposal is the least preferred waste management method under the 1984 HSWA. The HSWA landfill disposal restrictions imposed on certain wastes are addressed, however. It is recommended that it be clearly stated in this assessment report that land disposal is not the preferred alternative, and that alternate treatment technologies will be evaluated in the Feasibility Study.

Response: It is agreed that the hazardous waste land disposal facility assessment is simply one technical alternative within the determination of CERCLA cleanup and feasibility study process. This assessment presents technical, cost, and environmental analyses in support of the CERCLA process of interim actions, RI/FS, and remedial actions.

It is agreed that land disposal is the least preferred waste management method for complete site cleanup. However, it does provide a method for handling both the nonhazardous contaminated soils and solid residues from hazardous waste and CERCLA treatment processes, and as such merits attention to meet the future cleanup needs for the Rocky Mountain Arsenal.

The comprehensive nature of the assessment is due to the multiple purposes that this document was asked to address and the complexity of the RI/FS process for more than 100 potential cleanup sites on one facility. The multiple purposes of this task were to characterize the various wastes potentially requiring land disposal, select a suitable on-site facility with enough detail for a feasibility level estimate of schedule and costs, and estimate schedules and costs for construction and post construction monitoring including site development, operation, closure, and post-closure care. The complexity of the RI/FS process means that assessment of the basic information associated with this feasibility study drives the process to a data intensive investigation. The feasibility studies are part of a process of identifying cleanup choices for numerous sites within RMA. The land disposal facility is a logical alternative, and potentially part of the management of future wastes produced in the cleanup effort rather than the preferred alternative as the primary cleanup technology.

Technical Comments: The following comments/recommendations are offered in the event that the land disposal concept enters the design stage:

Comment 1: Pages 3-14 and 3-15 (Volume I), Avoidance Area Criterion: It is stated that these include "known contaminated areas". Comparison with the tricolor maps shows that identified contamination sites are within the land disposal areas under consideration. What effect will this have on the use of clean subsoil for berm construction (page III-4, Volume II)? It is recommended that the report state that soil from contaminated areas would not be used for berm construction.

Response: No effect should occur from these minor potentially contaminated sites, which will be cleaned up before placement of a waste cell on these areas. Enough clean area exists to begin disposal operations and to simultaneously clean up these minor potentially contaminated sites.

The text has been changed to indicate that the clean fill is from uncontaminated areas.

Comment 2: Pages 4-9, 5-13 and 6-3 (Volume I): Control of storm-water run-on/off is described on these pages. The Colorado Hazardous Waste Regulations (6 CCR 1007-3) specifically state in Part 264.301(c) and (d) that these controls must be able to control run-on/off from the 100-year storm. Was the 100-year storm considered in this preliminary design? Future design should specifically address the 100-year storm.

Response: The assessment did not include detailed design of features relating to handling the 100-year storm. The schemes shown in the report are only conceptual. Detailed design would specifically address the 100-year storm as identified in Section 4.2.2.2, page 4-8.

Comment 3: Pages 5-28 (Volume I) and III-32 (Volume II): On page 5-28 it is stated that "the leachate collection system is assumed to be operated for only the first 30 years of the life of the facility". On page III-32 it is more correctly indicated that one of the requirements of the post closure care period is that the leachate collection and removal system must be operated until leachate is no longer detected. Although the post-closure care period is 30 years, it is important to note that the post closure care period may be extended beyond 30 years from the end of the closure period. In this regard, the statement on page 5-28 is misleading.

Response: The statement from Appendix II page III-32 has been added to the end of the sentence on page 5-28, which now reads: "The leachate collection system is assumed to be operated until leachate is no longer detected."

Comment 4: Page 5-32, last paragraph and Table 5-6 (Volume 1): Some of the calculations presented on Table 5-6 are incorrect, probably as a result of typographical errors. Specifically, "clay barrier soil storage" should be 1.8 inches, not .108 inches. Also, it appears that waste layer "In Situ (saturation)" should be .238 instead of .0238 and "storage capacity" would then be .018. These values would then result in the soil storage and travel time estimates shown on the table (see calculation brief attached to this memo). On page 3-12 it is indicated that a 40-foot depth to water contributes 852 years towards satisfying the 1,000-year isolation criterion. However on Table 5-6 it appears that the 40-foot depth to water contributes 827 years. These values should be consistent with each other. Finally, it is recommended that in the design stage travel time calculations be repeated using site-specific soil data.

Response: The errors in Table 5-6 and page 3-12 have been corrected. Site-specific soil data would be used in final design; a program for obtaining such data is defined in Appendix V (Volume II).

Comment 5: Page 5-37 (Volume I) and page III-4 (Volume II): On page 5-37 (third paragraph) it is indicated that leachate from the leachate detection layer will be piped to a leachate pond during the post closure care period. On page III-4 it is stated that during operation and post closure care periods contaminated run-off would be trucked and pumped to the leachate treatment pond. Additional information is warranted on this pond in light of the fact that it may be a regulated surface impoundment.

Response: A careful reading of page 5-37, Volume I, shows that the pipe flow is used for leachate transfer after the post closure period. Additional description has been added to reflect leachate pond operation as a regulated surface impoundment.

Comment 6: Volume II, Section I (Waste Characterization) and Section V (Recommendations for Confirmatory Work): Wastes are characterized based on the most current information from the ongoing Remedial Investigation. In Section V it is recommended that waste compatibilities and liner/waste compatibilities be evaluated in a testing program. Proposed test methods should have been included. Also, there is no discussion of, or a proposal to evaluate waste mobility in the unsaturated zone or groundwater. Although this is not a specific regulatory requirement, it is recommended that such an evaluation be performed in future design studies.

Response: Standard test methods, as recommended by EPA, would be used for waste-to-waste and waste-to-liner compatibility evaluations; testing program design is beyond the scope of this Assessment.

Waste mobility in the unsaturated zone is addressed in Section 5.4.3, Environmental and Public Health Implications, in which deep percolation of leachate is discussed; the discussion does not cover mobility in the groundwater because the travel time of groundwater to the site boundary is probably very short compared to unsaturated zone travel time.

The Army has received no response or comments on the Task 27 draft final report from the state of Colorado.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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Colonel W. N. Quintrell
Program Manager
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Re: Rocky Mountain Arsenal (RMA)
Review of Draft Final Report
for Task 27, Hazardous Waste
Land Disposal Facility
Assessment.

Dear Colonel Quintrell:

EPA Region VIII has reviewed the above-referenced draft report. We have two major areas of concern.

This Draft report includes the Army's "preliminary review" of Federal and State "Applicable or Relevant and Appropriate Requirements" (ARAR's). EPA has not yet addressed ARAR's for such a landfill. Further, we have not reviewed this preliminary design for compliance with RCRA landfill design and operation requirements. Ultimately, these landfill requirements will have to be met as ARAR's and their impact be incorporated into the Task 28 Feasibility Study evaluation of alternatives.

Additionally, the assumption of the average annual precipitation rate has been questioned and needs to be reviewed. If in fact the assumption is revised, the implications of precipitation rate will also need revision.

Enclosed please find preliminary comments from our contractors. Our contact in this matter is Mr. Connally Mears at (303) 293-1528.

Sincerely yours,

Robert L. Duprey, Director
Hazardous Waste Management Division

Enclosure

cc: David Shelton, CDH
Chris Hahn, Shell Oil Company
R. D. Lundahl, Shell Oil Company
Thomas Bick, Department of Justice
Elliott Laws, Department of Justice
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